SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1898.

GENERAL PHYSICS.

1107. *Theory of Deformation of Metals.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 377–404, 1898.)—As a result of microscopical examination and metallurgical investigation, the ordinary metals used in construction are assumed in this memoir to be composed of a great number of very small crystalline elements or grains embedded in a network of viscous matter. The crystalline elements are supposed to be possessed of elasticity but to be deprived of viscosity, whilst the surrounding network is deprived of elasticity. The author then proceeds to show how the laws of permanent deformation follow from this assumption. The present memoir deals with homogeneous deformation. Hooke's law is assumed for the elasticity of the crystals, whilst the linear law expresses the viscosity. The deformations due to the crystalline and viscous components of the metal are then calculated, the former being simply the ordinary elastic deformations, and the latter being obtained by integrating the ordinary equations for a viscous fluid for the form of the network in question. The total deformation is thus shown to consist of a term representing the elastic deformation of the crystalline elements, and a term consisting of some function of $\int_0^t X dt$, (X being the deforming force and t the time), which represents the viscous deformation. The author lays great stress upon the importance of taking account of the time in making experimental tests, especially where stops are made with the specimen under load, and states that many of the irregularities in the results obtained in mechanical laboratories, which have usually been put down to faults in the metal, may probably be accounted for by neglect of this precaution.

The equation obtained for the deformation is then put into the following form

$$x = KX + \phi\left(\int_0^t X\,dt + A\right) - \phi A,$$

X being the force and x the length, and A being a constant depending on the initial state of hardness of the metal. For a rapid variation of load without shock the deformation is shown to be elastic, and the coefficient of elasticity is defined as being fixed by the amount of the sudden variation of the deformation when produced without shock. Thus to obtain the coefficient of elasticity it is necessary to measure the initial value of the alteration of the deformation. It is then shown that after a stop of great length under the action of a load, a small deformation effected rapidly without shock is purely elastic. Considering the case of deformation produced at a constant rate, the author shows that the resulting relations agree with the law discovered by M. Bouasse in his experiments upon the torsion of a platinum wire (Comptes Rendus, Feb. 1897). After discussing the case of a cycle performed at a constant rate interrupted by stops under load, the author gives some geometrical illustrations of the foregoing, and concludes by indicating the treatment of torsion and bending and also the influence of temperature and physical properties of the metals on the function ϕ. A. Gs.

1108. *Solar Radiation in the High Alps.* **G. B. Rizzo.** (N. Cimento, 4. 7. pp. 120–130, 1898.)—The formulæ of Pouillet ($Q = Ap^{\epsilon}$), Crova ($Q = A/\overline{(1+\epsilon)}^{m}$), and Bartoli ($Q\epsilon^{n} = K$), for the quantity of solar heat incident per unit of normal area, though Crova's works best, are all subject to the objection that when the sun is in the zenith ($\epsilon = 0$), the values obtained for the solar constant become inadmissible, as they also do with Ångström's binomial formula, $Q = (2{\cdot}568 \times 0{\cdot}751^{\epsilon}) + (10{\cdot}335 \times 0{\cdot}049^{\epsilon})$. Observations made on the Rocciamelone in the Val de Susa, at different heights, gave on reduction the formula $Q_1 = a - b\mu^{n}$ for the value of the solar radiation considered as zenithal, μ being the mass of air already traversed by that radiation: and the solar constant has a value very near 2·5 small calories per minute and per square centimetre, this value being of course apart from that of any particular radiations to which the upper regions of the atmosphere may be opaque. A. D.

1109. *Surface Tension of Gold.* **G. Quincke.** (Annal. Phys. Chem. 64. 3. pp. 618–619, 1898).—Heydweiller has recently found the specific cohesion of gold to be 6·90 mm.^{2}, and considered Quincke's value, equal to the specific cohesion of water, or roughly 2 × 8·5 mm.^{2}, as much too high. Quincke now defends his value and attributes the lowness of Heydweiller's to the one half per cent. impurity which his gold contained; the gold used by Quincke having been perfectly pure. J. B. H.

1110. *Capillary Constants from Drops.* **A. Heydweiller.** (Annal. Phys. Chem. 65. 2. pp. 311–319, 1898.)—The author compares Poisson's, Lohnstein's, and Siedentopf's methods of determining the surface-tension of a liquid from the dimensions of a drop. He then draws up a table, based chiefly on Lohnstein's work, by means of which anyone can calculate, with ease, the specific cohesion of the liquid. He applies this table to certain observations of Quincke and Sieg. A. Gs.

1111. *Hydrogen in Nebulæ.* **J. Scheiner.** (Ast. Phys. Journ. 7. pp. 231–238, 1898.)—It is well known that the spectrum of hydrogen in the nebulæ is different from that in an ordinary vacuum-tube, in the fact that whereas in nebulæ $H\beta(\lambda 4861)$ is well seen, $H\alpha(6561)$ is almost invisible or entirely so; in a tube $H\alpha$ is usually brighter than $H\beta$. $H\alpha$ has so far only been observed in one nebula (G.C. 4390), by Keeler, and then very faintly. Experiments in the laboratory show that by reduction of intensity the spectrum in a vacuum-tube may be reduced to $H\beta$ in the green-blue. The conditions present in case of nebulæ are (1) extreme attenuation of particles, and (2) temperature probably approaching absolute zero. The first condition has been imitated by examining the hydrogen in large wide tubes very highly exhausted, and excited by feeble discharges. Throughout these proceedings it is found that as intensity is reduced, $H\alpha$ disappears first, leaving $H\beta$ only visible. The second condition has been experimented on by Koch (Wied. Ann. 38. 1889), who used wide Geissler tubes kept at a temperature of $-80°$ to $-100°$ C. by means of solid carbonic acid and ether. No appearance of any change in spectrum could be detected. The author has since repeated this experiment with temperatures as low as $-200°$ C., using liquid air. His observations entirely confirm those of Koch in that no change was seen. The phenomenon was then thought to be possibly physiological, and a number of experiments are described which render this probable. He found that with the same tube he could obtain a gradual change of the $H\alpha$ line from being brighter than $H\beta$, to equality and then completely vanishing, by simply decreasing the light emitted by the tube. From this he concludes that the appearance is purely physiological, and if this is so, great importance must be attached to it, as it is impossible to base any conclusions on the physical constitution of the nebulæ from this peculiarity of the spectrum of hydrogen. C. P. B.

1112. *Hoffmann's Formula for Oceanography.* **F. v. Wrangell.** (Annal. Phys. Chem. 65. 1. pp. 237–240, 1898.)—In this paper the author draws attention to a false formula in connection with deep-sea currents, which was first printed by Hoffmann in his work 'Zur Mechanik der Meeresströmungen,' and has been copied from there into several other treatises on the subject. Zöppritz showed that in a mass of water of unlimited depth and infinite extension, if the surface were set in motion with a uniform velocity

w_0, then the depths to which any particular velocity less than w_0 would have penetrated after certain intervals of time are proportional to the square roots of these intervals. The formula giving the velocity v at time t, at depth x, is

$$v=w_0\left\{1-\frac{2}{\sqrt{\pi}}\int_0^{x/2\sqrt{ut/k}} e^{-z^2}dz\right\},$$

where u = specific gravity, and k = 0·0144 the viscosity of water. This formula Hoffmann transformed into

$$\sqrt{t}=1736\,.\,h\,.\,\frac{1}{n},$$

where h is the depth and $\frac{1}{n}$ the velocity, the surface velocity being taken as unity. Hoffmann's formula is shown not to be even approximately correct by taking particular values and evaluating the above integral. J. B. H.

1113. *Superficial Conducting Films.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 365–367, 1898.)—Following up a previous research, the author experimented on surfaces of rock-salt, and found that the current became stationary in a comparatively short time (about 2 min. over concentrated sulphuric acid). He concludes that for really homogeneous and continuous conducting films there is no polarisation; and that conversely the absence of polarisation is a test for the presence of such a film. The film which forms upon rock-salt shows a smaller vapour-tension than a saturated solution of sodium chloride; and the thickness of the film is regulated by the tension of aqueous vapour prevailing at the time. G. B. M.

1114. *Harmonic Analysis.* **S. Berson.** (Écl. Électr. 15. pp. 287–289, 1898.)—A graphical method applicable to periodic functions containing only odd harmonics, and worked out with special reference to a function containing no higher harmonics than the 5th. Let the function be $E_x=S_x+C_x$, where

$$S_x=a_1\sin x+a_3\sin 3x+a_5\sin 5x,$$

and

$$C_x=b_1\cos x+b_3\cos 3x+b_5\cos 5x.$$

The first step consists in splitting E_x into its sine and cosine terms respectively. Since on substituting $180°-x$ for x we obtain $E_{180°-x}=S_x-C_x$, it follows that

$$S_x=\tfrac{1}{2}(E_x+E_{180°-x}),$$

and

$$C_x=\tfrac{1}{2}(E_x-E_{180°-x}).$$

Let in fig. 1 the full-line curve represent E_x, plotted in polar coordinates. Take any two points P and Q, such that OP and OQ are equally inclined to the axes, and from M, the middle point of the intercept P′Q′ on the vertical axis by the perpendiculars from P and Q, draw a perpendicular to intersect the radii vectores to P and Q in R and S respectively. Then R and S are two points on S_x; by choosing a sufficient number of points, the S_x curve (shown dotted) may be drawn. From this the C_x curve (shown chain-dotted) is at once deduced. In order to effect the analysis

Fig. 1.

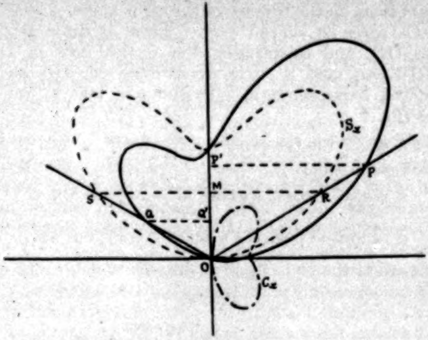
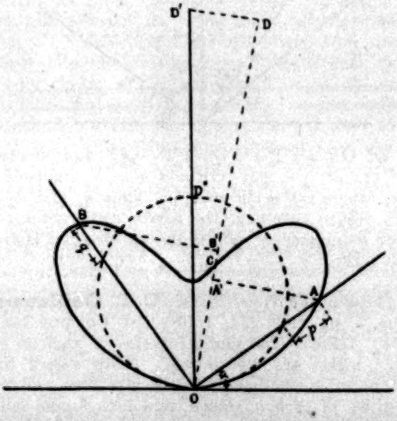


Fig. 2.



of either component curve, say S_x, into its simple harmonic terms, the equation

$$2a_1 \sin(45^\circ + x) = S_x/\sqrt{2} + S_{90^\circ+x}/\sqrt{2} + S_{45^\circ+x}$$

is made use of to evaluate the principal term. In fig. 2, the full-line curve represents S_x. Take two points, A and B, separated by 90°, and project them on the bisector of the right angle. Then OD=OA′+OB′+OC gives $2a_1 \sin(45^\circ + x)$. From D draw DD′ at right angles to OD, and intersecting the vertical axis in D′. Then OD″=½OD′=a_1, and a circle constructed on OD″ as diameter gives the first harmonic term. To obtain a_3 and a_5, we have the equations (fig. 2):

$$p = a_3 \sin 3x + a_5 \sin 5x, \text{ and } q = -a_3 \cos 3x + a_5 \cos 5x,$$

from which we obtain:

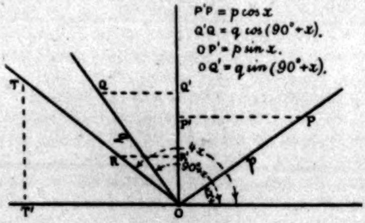
$$a_3 + a_5 = [p \cos x + q \cos(90^\circ + x)]/\sin 4x,$$

and

$$a_3 - a_5 = -[p \sin x + q \sin(90^\circ + x)]/\cos 4x.$$

The construction shown in fig. 3 enables us to determine a_3 and a_5.

Fig. 3.



By laying off OR′=P′P+Q′Q=P′P−QQ′ and erecting a perpendicular at R′ we get OR $= a_3 + a_5$. Similarly we find OT $= a_3 - a_5$, where OT′=OP′+OQ′. Thus a_3 and a_5 are determined. To secure accuracy, the above constructions should be repeated for a number of points on the original curve, and the mean result taken.

A. H.

1115. *Properties of Nickel-Steels.* **C. E. Guillaume.** (Journ. de Physique, 7. pp. 262–274, 1898; also Comptes Rendus, 126. pp. 738–740, 1898.)—The characteristics of various compounds of iron and nickel are considered. With regard to *magnetic properties*: nickel-steels containing besides iron and nickel only small quantities of carbon, silicon, and manganese, fall into two distinct categories. The first containing from 0 to about 25 °/₀ of nickel, and which seem comprised pretty accurately between the formulæ Fe and Fe_3Ni, are "irreversible" in the sense that at one and the same temperature they can exist in two essentially different states, according to the preceding cycle of temperatures. When these alloys are heated they lose their magnetism gradually between two temperatures, which are comprised for all the alloys between dull red and cherry red. When they are cooled they pass again through the same temperatures without becoming magnetic, and only reacquire their first condition at a temperature lower than those between which the loss of magnetism occurs. The return to the magnetic state takes place for an alloy with 24 °/₀ nickel a little below zero. The presence of chromium lowers the temperature at which the return takes place. The steel with 22 °/₀ nickel and 3 °/₀ chromium remains non-magnetic even in liquid air. Steels with more than 25 °/₀ nickel are "reversible," and possess at each temperature magnetic properties which to a first approximation depend only on the actual temperature. The *expansion* of the material has been observed by comparison with a brass scale. The phenomenon noticed by A. Le Chatelier has been confirmed: the expansion for the same alloy is much more feeble in the magnetic state than in the non-magnetic state. The transformation is gradual as regards expansion as well as regards magnetism, and the same alloy may possess any coefficient of expansion between two determined limits according to its degree of transformation. In one of the extreme states the expansion is a little greater than that of brass, in the other it is lower than that of ordinary steels. At ordinary temperatures the steels of the second category possess a coefficient of expansion which varies continuously with the composition. Steels containing 35 to 36 °/₀ of nickel expand ten times less than platinum. Other *mechanical* constants and their changes are also referred to. The alloys of the first group in passing from their non-magnetic state, where they are relatively soft and easily deformed, to the magnetic state when they become hard and very elastic, undergo a diminution of the modulus of elasticity. The nickel-steels possess a high specific resistance, and the transformations which they undergo do not seem to affect the variations of the electric resistance, the curve of change is an ordinary one. The variation of resistance with temperature seems to be independent of the variations of volume. For the alloys of the first sort the passage to the magnetic state takes place with increase of volume. A chemical origin is suggested for the peculiarities of behaviour, and it is supposed that definite chemical compounds tend to be formed. The experiments show that the irreversible nickel-steels can possess between extended limits of temperature an indefinite number of states of equilibrium, which they keep almost without modification so long as the alloy does not cut, at low or high temperatures, two curves of transformation along which all its properties change gradually and simultaneously. They possess besides unstable states of equilibrium which can be broken quickly, and to which an almost instantaneous transformation puts an end. See also Phys. Soc. Abstracts, Nos. 469 and 517, 1897. J. J. S.

LIGHT.

1116. *Astronomical Refraction.* **P. Pizzetti.** (Atti R. Accad. Sci., Turin, 33. pp. 137–151, 1898.)—Bessel's theory is based on the hypothesis that the temperature t of the air varies with the height h above the earth according to the equation

$$\frac{1+\epsilon t}{1+\epsilon t_0}=e^{-k\frac{h}{a+h}},$$

where t_0 is the temperature at the earth's surface, ϵ the coefficient of thermal dilatation of air, a the mean radius of the earth, and k a constant. But his formulæ when reduced to figures give a fall of 1° C. for 815 metres of ascent at the earth's surface; which is inadmissible. Besides, it follows from Bessel's formulæ that the fall of temperature is nearly the same whatever the initial temperature t_0, whereas it is really more rapid the higher the value of t_0. The author starts from Mendelejeff's law (deduced empirically from Glaisher's observations) that

$$t=a+bp,$$

where t and p are the temperature and pressure, and a, b are constants ($a=-36°$). He then proceeds by analysis (which does not lend itself to abridgment), and finds that near the earth the fall is 1° per 307, 222, 174, 150, 134 metres of ascent when the earth-temperatures are respectively −10°, 0°, 10°, 20°, 30°. The pressure and the temperature both fall off more and more slowly as the height increases. The author reaches an expression for the refraction, of the form

$$\mathrm{R}=\frac{\alpha\sqrt{2\gamma}}{1-\alpha}\sum_{1}^{\infty}\mathrm{C}_n\sqrt{n}\,.\,e^{\mathrm{T}^2}\int e^{-x^2}dx,$$

which gives results in harmony both with the observed refractions and with the observed variations in temperature. A. D.

1117. *Phase-Reversal Zone-Plates and Diffraction Telescopes.* **R. W. Wood.** (Phil. Mag. 45. pp. 511–522, 1898.)—It was demonstrated by Soret that if we describe on a plate of glass a series of circles with radii proportional to the square roots of the natural numbers, and render the alternate rings opaque to light, the plate will have the property of bringing parallel rays of light to a focus like a condensing-lens. The opaque rings cut off the disturbances from the alternate Huyghens zones, which by destructive interference with the waves from the other zones produce the phenomena of shadows. Lord Rayleigh has pointed out that if it were possible to provide that the light, instead of being cut off by the alternate zones, should suffer a phase-reversal, the illumination at the focus would be four times as great as with the Soret form of plate. This has been accomplished by preparing zone-plates with rings of thin transparent gelatine of such thickness as to retard the light-waves one-half wavelength, thus securing the required phase-reversal. The plates produce much more brilliant images than the usual form; and by using one of five-feet focus as the objective of a telescope, some of the larger lunar craters could be made out. The plates were made by preparing a drawing of 230 concentric rings of the requisite diameter, blackening the alternate spaces, and reducing the drawing to the size of a shilling by means of photography. From the negative, prints were made on plate glass, sensitised with an exceedingly thin film of bichromatised gelatine. On washing in warm water, the rings unaffected by light were dissolved away. Smaller plates of six inches focus were prepared by photographing the original with a microscope objective; and a number of photographs of winter landscapes were made, using the zone-plate instead of the camera lens. These photographs have a peculiar quality, and some are very artistic; but much has been lost by reproduction. The originals somewhat resemble charcoal sketches. Where a mass of twigs and branches appear against the sky, there is a background of shadow over the whole, although the definition is fairly good. The ratio of aperture to focus was about F 32, much smaller than in the case of pin-hole photography.

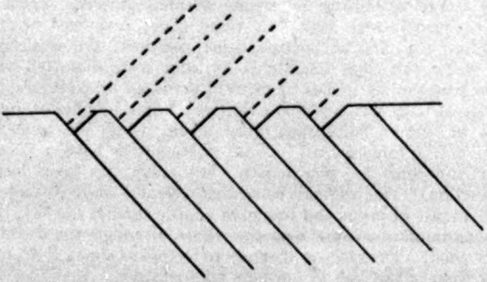
Phase-reversal plates were also made by making the alternate zones of silver and mounting the plate on the reflecting surface of a right-angle prism. These plates operated by reflection, the reversal of phase being introduced by the metallic and total internal reflection.

With the paper is a reproduction in black-and-white of the original drawing, from which anyone with a camera can make zone-plates either of the Soret or phase-reversal type. AUTHOR.

1118. *Spectroscope without Prisms or Gratings.* **A. A. Michelson.** (Astr. Phys. Journ. 8. pp. 37–47, 1898.)—The author gives a complete description of the instrument and its theory, of which he wrote a short preliminary note in the Am. Jour. Sc. for March 1898 (see Abstract No. 754). The resolving-power of a grating, being proportional to the product of the total number of lines by the order of spectrum observed, may be increased by increasing either of these factors. Hitherto it has been the first factor, the number of lines, which has received attention; but the author now brings forward a method of using the second, viz. increasing the order observed, with great efficiency.

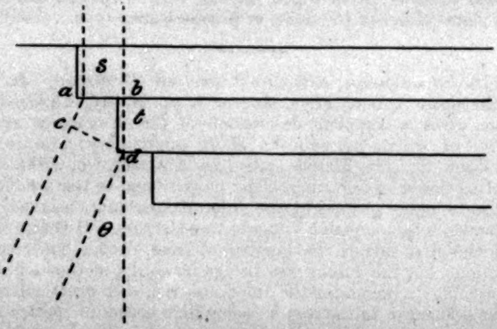
The difficulties in the way of using high orders in spectra have been very great, as with the ordinary form of grating the intensity very rapidly diminishes as the order is raised, and the *accuracy* of ruling is very influential. It seemed to him quite possible to construct gratings which would throw a considerable percentage of the incident light into high orders of spectra—say, the hundredth,—to do this it being necessary that the grating-space should be of the order of a *hundred waves*, *i. e.* about *twenty* to the millimeter, instead of a *thousand* as at present. The lines would have to be drawn with no more accuracy than before, and in addition the grating could be made in less time, and therefore temperature and local changes would have much less injurious effect than at present during the ruling operations.

Fig. 1.



The author's first idea was to build up a grating by equal thicknesses of optical glass placed in a series of steps as in fig. 1, the whole being used as a reflection-grating, the grating-space being the distance by which each step is set back from its neighbour. In this form, however, he found great optical difficulties, especially in joining the successive steps so that there should always be the same distance between each pair. By using

Fig. 2.



the arrangement for transmission, however, this difficulty is removed; and the only difficulty remaining is that of making a considerable number of plane-parallel plates of the same thickness, to an order of accuracy of only one-fourth that required by other methods, and only one-tenth if the other medium be oil or water instead of air. A striking feature of the idea is the small number of plates required to give a resolving power comparable to that of the best fine-ruled gratings.

Let *abd* be one step in the series of plates, and let $ab=s$ and $bd=t$. If m is the order of spectrum observed,

$$m\lambda = \mu \, . \, bd - ac,$$

or

$$m\lambda = \mu t - t\cos\theta + s\sin\theta,$$

$$\frac{d\theta}{d\lambda} = \frac{m - t\dfrac{d\mu}{d\lambda}}{t\sin\theta + s\cos\theta},$$

$$\frac{d\theta_1}{dm} = \frac{\lambda}{t\sin\theta + s\cos\theta};$$

and if $\delta\theta$ is the displacement corresponding to $\delta\lambda$, and $\delta\theta_1$ that corresponding to $\delta m = 1$, assuming Cauchy's formula

$$\mu = a + \frac{b}{\lambda^2},$$

and taking the approximate value of

$$m = \frac{(\mu - 1)t}{\lambda},$$

we have

$$\frac{\delta\theta}{\delta\theta_1} = [(\mu-1) + 2(\mu - a)]\frac{t}{\lambda} \, . \, \frac{\delta\lambda}{\lambda}.$$

For flint glass the coefficient of $\frac{t}{\lambda}$ is approximately equal to *unity*; so that if

$$\frac{\delta\lambda}{\lambda} = \cdot 001,$$

as in the case of the two sodium-lines, and $t = 5$ mm. $= 10{,}000\,\lambda$, then

$$d\theta = 10\, d\theta_1;$$

that is, the sodium-lines would be separated by ten times the distance between the spectra.

The resolving power of such a combination is mn, just as in the case of gratings; so that with but *twenty* elements 5 mm. thick, and hence $m = 5000$, the resolving power would be 100,000, which is about equal to that of the best gratings. The experiment was first tried with but *seven* elements; but even with this the Zeeman effect was easily detected when the sodium-lines were placed in a magnetic field. It is important to note that the resolving power is independent of the *number* of plates, but depends on the *total thickness*, the advantage of a larger number of plates being the greater separation of the spectra.

A spectroscope on this plan has been constructed in the Ryerson Physical Laboratory and is illustrated in the paper. This has twenty elements, each plate being 18 mm. thick, their widths diminishing from 22 mm. to 2 mm., the successive retardations produced being of the order of 20,000 waves. It is then evident that practically all the light can be concentrated in one spectrum, the only losses being due to reflection and absorption, and these are probably less than in either gratings or prisms of equal resolving power.

An interesting and extremely valuable method of testing the plates for parallelism and flatness is given in the paper, which is based on the use of interference-bands shown with monochromatic light (in this case the green radiation of mercury). With this the plates can be worked to an accuracy corresponding to one-eightieth of a wave, which will fulfil all likely requirements.

As a test of the performance of the echelon spectroscope, the author gives a series of measurements of the Zeeman effects on several different radiations, the results being very similar to those he has already obtained by other means. The theoretical resolving power of the instrument illustrated is about 300,000, which he finds slightly too low to examine several radiations for complexity; and his next step is the building of a spectroscope having *five* times the resolution of the present one. C. P. B.

1119. *Rotatory Power of Quartz in the Infra-red.* **Dongier.** (Paris Soc. Franç. Phys., Bull. 105. pp. 1–4, 1898.)—The method of measurement is described. The formula proposed is

$$\rho = (\mathrm{A}n^2 - \mathrm{B})/\lambda^2 + c/(\lambda - 3{\cdot}2)^2.$$

M. Carvallo, whose formula is

$$\rho\lambda^2 = (\mathrm{A}n^2 - \mathrm{B}) \text{ simply,}$$

pointed out that the proposed formula would make the rotatory power infinite for $\lambda = 3^{\mu}{\cdot}2$, which was very unlikely; and that it would meet requirements to make the equation

$$\rho\lambda^2 = \mathrm{A}n^2 - \mathrm{B} + \mathrm{C}\lambda^2,$$

where C is 0·240 for M. Dongier's quartz, but would vary with the samples. M. Carvallo also dealt with Becquerel's law of magnetic rotatory dispersion,

$$\rho = -\mathrm{K}\lambda \,.\, dn/d\lambda,$$

and showed that by bringing it to the form

$$\int_{\lambda_0}^{\lambda_2} \rho d(\log\lambda) = -K(n_1 - n_0)$$

it involved measurable terms, and on plotting these out the formula was found to agree fairly well with observations. A. D.

1120. *Infra-red Dispersion of Quartz.* **E. Carvallo.** (Comptes Rendus, 126. pp. 728–731, 1898.)—Measurements are given of the indices of refraction of quartz: these were made with the aid of a prism of quartz and of a thermoscopic apparatus for the infra-red part. The observations are stated to be of great precision, and are given to five places of decimals. A simple numeration of the fringes gives an indication of the difference of phase, φ, established between the two rays by the quartz-plate. These data allow the wave-length, λ, of the fringes used as lines of reference to be calculated from the formula

$$\lambda = \frac{(n'-n)e}{\varphi},$$

where n and n' are the ordinary and extraordinary indices, and e the thickness of the quartz plate. J. J. S.

1121. *Rotatory Dispersion of Quartz.* **E. Gumlich.** (Annal. Phys. Chem. 64. 2. pp. 333–359, 1898.)—The rotation produced by quartz-plates was measured for different wave-lengths throughout the visible spectrum, a form of Half-shadow apparatus due to Lummer being used for the measurements. The results were applied to a number of theoretical formulæ given by different writers for the rotation, and that due to Boltzman satisfies best the results of the experiments. Considering only the visible spectrum, three terms of the series suffice; but if the results of other investigators on the infra-red and ultra-violet are included, then five terms are required. The formula then is

$$\phi = \frac{7{\cdot}08114}{10^6.\lambda^2} + \frac{0{\cdot}173321}{10^{12}.\lambda^4} - \frac{0{\cdot}0056761}{10^{18}.\lambda^6} + \frac{0{\cdot}00042255}{10^{24}.\lambda^8} - \frac{0{\cdot}0000075338}{10^{30}.\lambda^{10}},$$

where ϕ is the specific rotation and λ the wave-length in millims.

The temperature-coefficient is found to be independent of the wave-length between the limits $\lambda = 656\,\mu\mu$ and $\lambda = 436\,\mu\mu$. For the interval 0° to 100° C. the formula is

$$\varphi_t = \phi_0[1 + 0{\cdot}000131t + 0{\cdot}0_6195t^2],$$

and at about 20° for small differences the linear formula

$$\phi_{20} = \phi_t[1 + 0{\cdot}0_314(20^\circ - t^\circ)]$$

suffices. J. B. H.

1122. *Radiation from Rock-salt.* **M. Abramczyk.** (Annal. Phys. Chem. 64. 4. pp. 625–654, 1898.)—The objects of this investigation were to discover:—(1) Is the radiant heat emitted by rock-salt monochromatic? (2) If not monochromatic, how far can impurities in the rock-salt explain that monochromatism which has been observed? (3) Does the coefficient of absorption approach a very high value for diminishing temperature-difference between absorbent and radiator, both these being of rock-salt?

To test the first, the radiation from a heated plate of rock-salt 1 mm. thick was allowed to traverse one of a set of three plates of rock-salt 1, 2, and 3 mm. thick, and the absorption produced by each plate measured. A bolometric method was used for the measurements. The radiating plate was heated to different temperatures, but the absorbing plates were kept at 15° C. The results are best understood from the curves given in the paper; but if the coefficient of absorption is calculated from these it is found to be by no means constant, which it would be were the radiation monochromatic.

To determine the influence on the radiation of the minute globules of water or solution always present in the body of the rock-salt, the capillary space between two plates of rock-salt separated by thin strips of mica was filled with water, and the radiation emitted by the rock-salt and water compared with that emitted by the two plates alone. The presence of the water increased the radiation by about 48 per cent., and on passing it through a rock-salt plate almost none of the increase of radiation was absorbed.

The influences on the radiation of the thickness of the plates, and also the polish of their surfaces have been experimented on. The reflecting-power of rock-salt and the radiation from fused sodium chloride are also considered. J. B. H.

1123. *Residual Rays of Rock-salt and Sylvine.* **H. Rubens** and **E. Aschkinass.** (Annal. Phys. Chem. 65. 2. pp. 241–256, 1898.)—The authors have succeeded in isolating and examining in detail the extremely long heat-rays obtained by several successive reflections at the surface of rock-salt and sylvine. These rays are considerably beyond those obtained from quartz, mica, and fluorspar by a similar process. The measurement of their wave-length was rendered possible by the substitution of a sensitive thermopile for the bolometer. The thermocouple consists of 20 iron-constantan couples, whose odd junctions are arranged in a vertical line. The wave-lengths are determined by means of a grating consisting of silver wires 0·1858 mm. thick, with a grating constant of 0·3716 mm. The rays are derived from an Auer burner, and reach the thermopile after five successive reflections at the prepared surfaces of the salts. The result obtained for the wave-length of the residual rays of rock-salt is 51·4, and of sylvine 61·1. These wave-lengths are the longest hitherto obtained by optical means, and are 70 times smaller than the shortest waves hitherto attained on the electromagnetic side. In their properties they have indeed a closer resemblance to electromagnetic waves than to light waves. The rays in question are strongly absorbed by fluorspar, glass, calcspar, and hornsilver. Among liquids, water, alcohol, and ether absorb them entirely; carbon bisulphide, benzol, and petroleum transmit them; and olive oil transmits a large proportion of the sylvine rays while absorbing the rock-salt rays. Most of the bodies which transmit these rays belong to that class for which the dielectric constant is equal to the square of the refractive index for infinitely long waves. Such bodies have no absorption-bands in the infra-red spectrum. E. E. F.

1124. *Magnetic Rotatory Polarisation and Clausius' Axiom.* **M. Brillouin.** (Écl. Électr. 15. pp. 265–269, 1898.)—This is a criticism of a paper by W. Wien (Ann. Phys. Chem. 52. pp. 132–165, 1894), who asserted that by an optical apparatus there described it was possible to transfer radiant heat from the cooler to the hotter of two sources of light, in apparent contradiction of Clausius' axiom. In obtaining this result, reflections at the surfaces of the different media were neglected. Brillouin shows that it is necessary to take account of the whole series of reflections, and that when this is done the result is in accordance with the principle of Clausius. G. B. M.

1125. *Cornu's Theory of the Zeeman Effect.* **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 7. pp. 241–246, 1898.)—The author points out the fallacies in certain arguments of Righi's, which would, if correct, make Cornu's interpretation inadmissible. G. B. M.

1126. *Photographic Irradiation.* **Ch. Féry.** (Comptes Rendus, 126. pp. 890–893, 1898.)—This is the spreading of the image of a bright point. The corresponding part of the film acts as a secondary source of light and affects neighbouring portions, until the distance becomes such that by absorption the intensity of illumination falls below the limit at which any chemical change will be induced. This distance increases in arithmetical progression as the quantity of light increases in geometrical progression. Experiments with backed plates confirmed this result, which is independent of reflections from the glass and of the aberrations due to the lens. A. D.

1127. *Rontgen-Ray Tubes.* **H. L. Sayen.** (Frank. Instit. Journ. 145. pp. 441–446, 1898.)—The author describes a tube with an auxiliary tube containing some substance which gives off water-vapour on being heated: heat is applied by internal sparking in this auxiliary tube, adjustable as required so as to keep the vacuum constant at any desired value. A. D.

1128. *Visibility of Röntgen Rays.* **F. de Courmelles.** (Comptes Rendus, 126. pp. 919–921, 1898.)—Out of 240 pupils in the Blind School, nine (five females and four males) were found able to perceive Röntgen and kathode rays as colour, while two (one of each sex) perceived a painful sensation. Of the nine, two females and three males also perceived fluorescence rays from a platinocyanide screen under Röntgen rays. In all these cases the lesions causing blindness were peripherical, not central. A. D.

1129. *Radiography.* **F. Garrigou.** (Comptes Rendus, 126. pp. 1104–1105, 1898.)—If the rays from a focus-tube be restricted by passing them along tubes of glass or metal, the resultant image is clearer and gives more detail with shorter exposures. A. D.

1130. *Transparency to Röntgen Rays.* **F. Re.** (Elettricità, Milan, 17. pp. 261–264, 1898.)—On considering Dölter's scale of relative transparencies (diamond, corundum, talc, quartz, rock-salt, calcspar, cerusite, and realgar) it is seen that the transparency does not diminish with the increase of density or of molecular or atomic weight. Precisely in those cases where it can be said that the relative molecular distances are known, it is found that the transparency increases with the increase of these. In gases of simple molecular structure, the size of the molecules may be neglected in comparison with the molecular distances. Then in two gases the molecular distances are proportional to the cube roots of the respective molecular volumes, *i.e.*, of the molecular weights divided by the corresponding mass-densities. In liquids and solids we cannot neglect the relative size of the molecules in this manner; but with low densities and simple molecules, doing so may lead us towards some useful conclusions. In gases, the molecular distances being equal, the transparencies are about the same; in solids the differences are much greater. Vapours of thallium chloride, KBr, NaBr, are transparent: the salts in powder are opaque. Liquid bromine is opaque; bromine vapour is very transparent; and so on. In many cases the transparency falls off as the density increases; but monochloracetic acid is less transparent than trichloracetic (P. C. Frankland), alcohol is twice as transparent as water (O. Zoth). C, H, and O in a molecule tend towards transparency; but the introduction of chlorine, phosphorus, etc., introduces opacity. A high temperature in gases, increasing the molecular distances, increases the transparency. Cryptochrosis consists in this, that successive layers of a given substance are found to be proportionately more transparent to such Röntgen rays as have traversed the preceding layers. The author finds that it can be explained by assuming that the radiations undergo in each stratum a transformation into rays which are capable of traversing the succeeding strata. A. D.

1131. *Transformations of Röntgen Rays.* **G. Sagnac.** (Écl. Électr. 14. pp. 509–514, 547–555; and Comptes Rendus, 126. pp. 887–890, 1898.) (See Abstracts Nos. 245, 491, 765.)—The secondary rays discharge electric charges as Röntgen rays do. All substances emit secondary rays when struck by Röntgen rays; but like the photographic effect the discharging effect of these rays, when from aluminium, is much less in proportion than their effect on a fluorescent screen. Aluminium interposed in the path of the exciting Röntgen rays diminishes the discharging effect of the secondary rays much less than it does when interposed in the path of the secondary rays. The effect of Röntgen rays in inducing these secondary rays may be much greater than their effect upon the air traversed by the lines of force. The secondary rays render air electrically conductive in the same way as Röntgen rays do, and need not themselves impinge on the charged conductor. When Röntgen rays strike a charged conductor, there are three systems: the incident Röntgen rays, the secondary rays from the metal impinged upon, and secondary rays from the air itself. When secondary rays strike it there are tertiary rays formed, which are still more promptly absorbed by the air, rendering it conductive in a still thinner stratum round the charged conductor. The discharging effect of secondary rays increases with the volume of gas traversed by these rays, passing through a maximum in the case of a plane condenser, but continuously increasing in the case of a closed one. Every particle of a substance impinged on by Röntgen rays gives out secondary rays, subject always to the results of absorption of both kinds of rays. Röntgen rays may then be transformed by transmission through thin films, and secondary rays are transmitted in all directions from the surface of emergence of the Röntgen rays as well as from the surface of incidence. If aluminium be interposed between the source of Röntgen rays and a film of zinc, the secondary rays are much more powerful than if it be placed in the path of the secondary rays from the same film of zinc exposed directly to the Röntgen rays. The order of occurrence of films of different metals thus affects the apparent aggregate transparency to Röntgen rays. The films must be thin to show this. The production of secondary rays seems limited to about 0·5 micron in the case of gold, 1 mm. in that of aluminium. The total energy of the secondary rays is generally independent of the incidence of the Röntgen rays, and is proportional to the surface impinged upon: the energy received per unit of area, and the depth (measured along the normal) to which they travel both decrease according to the cosine law, and the actual proportion of the whole energy absorbed is the same in both cases for equal areas. When the obliquity is very great the thickness which must be obliquely traversed becomes too great, and the secondary radiation falls off in intensity.—The secondary rays from different metals differ in their penetrative power; and if any are not absorbed by the medium employed to detect them they produce no effect. Thus rays from aluminium produce very little photographic effect, but have a marked effect on platinocyanide of barium, which is not as good a means for distinguishing between different kinds of secondary rays as the photographic plate or electroscopy. As a rule the secondary rays are much more readily absorbed than the original Röntgen rays, and therefore produce effects disproportionate to their energies. The remainder of the energy absorbed from Röntgen rays, and not emergent in secondary rays, becomes heat (Dorn); and this will enable Röntgen-ray bolometers to be constructed. The secondary rays given out by air differ much less from the original Röntgen rays than do those given out, for example, by zinc. On the whole the phenomena are analogous to those of luminescence rather than of dispersion, and it may be that if Röntgen rays are of small wave-length, the wave-lengths are increased at each transformation. It appears that some of the transformed radiations (*e. g.*, those from zinc) dissipate negative charges a little more rapidly than positive, thereby approximating to the character of ultra-violet light, which dissipates negative charges only, as against Röntgen rays which dissipate positive and negative charges equally. Again, air is very opaque to ultra-violet radiation, and further photographic experiments should be made *in vacuo*. On the other hand, it may be that the Röntgen rays consist of small independent trains of waves; and in that case the result of composition of direct waves with waves which have been hampered, and the train lengthened, by obstacles would be equivalent to direct trains of waves of greater wave-length.—The process of transformation described is clearly not one of mere selection. A. D.

1132. *Transformations of Röntgen Rays.* **D. Hurmuzescu.** (Écl. Électr. 15. pp. 166–168, 1898.)—Results similar to those of Sagnac, extended to explain the fogging of plates by the harder short-exposure tubes now in use, and also the effects attributed to the so-called dark light. Röntgen rays facilitate discharge of a charged body in liquid and solid dielectrics as well as in gases: conclusion, that the discharge cannot be convective but must be conductive. A. D.

1133. *Polarisation of Röntgen Rays.* **L. Graetz.** (Annal. Phys. Chem. 65. 2. pp. 453–457, 1898.)—The author endeavoured to obtain X-rays ready polarised by letting the kathode rays impinge upon crystals. According to Sohncke all fluorescent crystals send out polarised light. The author used calcspar, tourmaline, andalusite, and dichroite. Now, if the X-rays proceeding from these crystals were polarised, a single tourmaline crystal outside could be used as analyser. The tourmaline tongs would be even more effective. Positive results appear to be obtained on the screen; but photographs showed no trace of polarisation, nor could it be detected with a Nicol. Further observations showed the apparently positive results to be due to inequalities on the fluorescent screen used for observation. It appears, then, that even with this powerful means polarised X-rays cannot be produced. E. E. F.

1134. *Influence of Röntgen Rays on Potential-gradient at Metal Electrodes.* **C. D. Child.** (Annal. Phys. Chem. 65. 1. pp. 152-163, 1898.)—The potential gradient between two metal discs kept at a constant difference of potential was experimentally determined by the author, a water-dropping electrometer being used to explore the region between the plates. This gradient is perfectly uniform under ordinary circumstances, but when Röntgen rays traverse the gap parallel to the plates this is no longer the case. The potential-gradent then becomes greater near the electrodes, and falls off towards the middle of the gap.

The paper contains a number of tables and curves giving the results of experiments made under a large range of conditions. The general conclusions deduced from these experiments are :—

1. The presence of Röntgen rays increases the potential-gradient near the surface of the metal.
2. This potential-gradient diminishes when the Röntgen rays strike the metal.
3. The potential-gradient diminishes most with those metals which absorb Röntgen rays most. J. B. H.

1135. *Becquerel Rays.* **O. M. Stewart.** (Phys. Rev. 6. pp. 239-251, 1898.)—An excellent historical *résumé.* A. D.

HEAT.

1136. *Specific Heat of Anhydrous Liquid Ammonia.* **L. A. Elleau** and **W. D. Ennis.** (Frank. Instit. Journ. 145. pp. 189–198, 280–293, 1898.)—The liquid employed was that commercially supplied by the National Ammonia Co. of St. Louis; it was tested for purity only by being allowed to evaporate, and then left only a trace of an oily residue due to the process of manufacture and too slight to be taken into account. The mean of nine experiments with a temperature range from 0° to 20° C. gives 1·0206, with a mean error of ±·0077. R. E. B.

1137. *Compressibility and Dilatation of Gases.* **A. Leduc.** (Journ. de Physique, 7. p. 5 & pp. 189–209, 1898.)—Substantially the same subject-matter as that of Abstract No. 300, worked out in more complete detail. A. D.

1138. *Absorbing Power of Lampblack.* **Crova** and **Compan.** (Comptes Rendus, 126. pp. 707–710, 1898.)—The absorbing power of lampblack for radiant energy is generally assumed equal to unity; in reality it varies within narrow limits with the nature of the black and its mode of application. Various values of the absorbing power have been stated by different authors. In the present paper an account is given of the absorption exercised on a flow of heat from a source at 100°. An absorbing power equal to unity is only theoretically to be obtained by receiving the flux on an orifice, made in an enclosure blackened in the interior, whose surface is negligible compared with that of the enclosure. The ratio of the emissive and absorbing powers being constant, the unit of emissive power is taken as that of an orifice made in a blackened enclosure heated to 100°. The finding of the absorbing power is thus reduced to that of the emissive power. The authors used a stove of copper filled with water at 100°, containing a hollow sphere of thin copper 7 cm. in diameter, blackened inside, and screwed in the interior to one of the sides on which it opens by an orifice of 2·2 cm. The flux which proceeds from an equal surface of the side of the stove adjacent to the orifice and blackened, is compared with that proceeding from the orifice itself. These fluxes were measured by being received on a thermopile connected to a galvanometer. In the result the loss per cent. of the absorption in the case of the copper of the stove was found to be from 0·522 to 0·650. For the same surface covered with black deposited from a candle-flame the loss was 0·068 to 0·1250. For one layer of lampblack washed with alcohol the loss was 0·317; for a number of layers (from 1 to 10), each layer being washed with alcohol, the loss regularly diminished to 0·0203.

The authors conclude that:—(1) A layer of lampblack applied in the ordinary way may have losses of absorption attaining to

0·1. (2) Light layers washed successively with alcohol give a resisting deposit and an absorption more and more complete, the loss not falling below 0·02. (3) Platinum-black, smoked and washed with alcohol, permits of arriving at the same limit with a fewer number of layers. J. J. S.

1139. *Conduction of Heat in Gases.* **S. R. v. Smolan.** (Annal. Phys. Chem. 64. 1. pp. 101–130, 1898.)—Experiments on the conduction of heat in rarefied gases are described. The analogy with the coefficient of viscosity is noticed, and the connection of the coefficients of conduction with the mean free path of the gas-molecules, which is deduced from the kinetic theory of gases, is clearly indicated in the results of the experiments. The experimental method adopted is essentially the same as that employed by Kundt and Warburg in their determination of the coefficients of conduction in gases. J. J. S.

1140. *Continuity of Liquid and Solid States.* **A. Heydweiller.** (Annal. Phys. Chem. 64. 4. pp. 725–734, 1898.)—This paper describes experiments undertaken to test the accuracy of experiments by Damien and also by Demerliac, which showed that the elevation of the melting-point of a substance by pressure is not proportional to the pressure, but that a maximum melting-point is reached, after which, according to Damien, increased pressure causes a fall in the melting-point. The author, by employing a capillary-tube method similar to that employed by Cagniard de la Tour for the critical state, has entirely failed to verify the above results, using the same substances as the others and pressures up to 2500 atmospheres.

Although failing at high pressures to show a continuity of the liquid and solid states, the author has succeeded in the case of menthol to show this continuity at temperatures below the melting-point. Liquid menthol when slightly supercooled, if placed in water at about 10° C., solidifies into a perfectly clear transparent solid, but if the water is about 13° C. it solidifies into the usual milky condition. The clear form is not stable, but changes very gradually into the milky one. If a capillary tube filled with liquid menthol have its bottom part immersed in a water-bath at 10° C., then the lower half of the menthol solidifies in the clear form and the solidification creeps slowly up the tube, the surface of separation between solid and liquid becoming gradually fainter until it finally disappears, although there is no difficulty in verifying that the top part of the column is still liquid.

J. B. H.

1141. *Condensation and Critical Phenomena of Mixtures of Two Substances.* **J. P. Kuenen.** (Zeitschr. Phys. Chem. 24. pp. 667–696, 1897.)—A given mixture (characterised by x, the volume-ratio of one of its components) behaves very much like a simple substance, and has isothermals of the same general character with this difference, that on a *pv*-diagram they slope upward towards the *p*-axis during the condensation-stage instead of being parallel to the *v*-axis. The true critical point R, or point of maximum temperature on the saturation-curve, will thus not coincide with the point M of maximum pressure on this curve, but will correspond to a less pressure and density.

On a *pt*-diagram the saturation-curves for the limiting values $x=0$ and 1 are the vapour-pressure lines of the pure components which end at their critical points, but for other values of x they form loops which are touched by their envelop in the plait-points P, where the critical phenomena occur that are dependent on the identity of coexisting phases.

These points on a saturation-curve may occur in the order PMR, MPR, or MRP, and it was to realise the last case, if possible, that the experiments in this paper were undertaken. Its peculiarity is that between the temperatures corresponding to P and R isothermal compression of the mixture causes retrograde condensation of the second kind, *i.e.* formation of a *less* dense (vapour) phase which first increases in amount, then decreases, and finally disappears.

Experiments were made with the pairs ethane and nitrous oxide, ethane and acetylene, ethane and carbonic acid, but the individual gases used were not themselves sufficiently pure to allow the expected phenomenon to be observed, though the course of the plait-point curve that was traced showed the possibility of its existence. The fact that one of the mixtures (*e.g.* ethane and nitrous oxide in the volume-ratio 1 : 4) behaves practically as a simple substance, and that for it the pressure at any temperature is a maximum was confirmed and extended up to the critical state; and it further appeared in all cases that addition of a little of either component to the other caused a *lowering* of the critical point, there being thus one mixture for each pair (*e.g.* C_2H_6 and N_2O as 1 : 1, C_2H_6 and CO_2 as 9 : 11) with a minimum critical temperature.

An interesting illustration of the character of the fold is given by drawing isothermals on a *vx*-diagram, where *v* represents the volume at either the beginning or end of the condensation: these consist of separate lines stretching from $x=0$ to $x=1$ while the temperature is below the minimum critical point; but above this point they form two branches, one of which begins and ends on the ordinate for $x=0$ and the other on that for $x=1$, one branch disappearing when the temperature reaches the lower of the critical points of the components, and the other when the higher is reached. R. E. B.

1142. *Graphics of the Thermodynamic Function.* **W. Fox.** (Frank. Instit. Journ. 145. pp. 214–227, 1898.)—Some very elementary propositions are here treated graphically by $t\phi$-diagrams; but nothing new is given even in this method, except perhaps the introduction graphically of Rankine's isodiabatic lines. R. E. B.

ELECTRICITY.

1143. *Electromagnetic Induction in Current Sheets.* **G. H. Bryan.** (Phil. Mag. 45. pp. 381–397, 1898.)—The "moving trails of images" so well known in connection with the theory of induced currents in a thin plane sheet are here extended to spherical sheets, and to cylindrical sheets when the inducing system produces a two-dimensional magnetic field. The images start from the source of disturbance and its inverse point and move radially away from the sheet, with velocities varying directly as the distance from the centre, the velocity at the surface of the sheet becoming equal to the velocity of the trails of images in a plane sheet (usually denoted by R). In the case of a cylindrical sheet, when the currents are induced by the generation of a line of poles or a straight current parallel to the axis, the images are of constant intensity equal to that of the source of disturbance. In the case of a spherical sheet, where the source of disturbance is a magnet whose axis points radially, the intensity of the images varies as the $\frac{3}{2}$th power of the distance from the centre. If the currents are induced in a spherical sheet by the generation of a single pole, the images on the *opposite* side of the sheet (representing the magnetic potential on the *same* side of the sheet as the pole) consist of a single pole and a uniform line distribution of magnetism of opposite sign extending to the centre of the sheet or to infinity, as the case may be, and being identical in character with the image of a source in a sphere in Hydrodynamics.

AUTHOR.

1144. *Calculation of Coefficient of Mutual Induction of a Circle and a Coaxial Helix, and of the Electromagnetic Force between a Helical Current and a Uniform Coaxial Circular Cylindrical Current Sheet.* **J. V. Jones.** (Roy. Soc. Proc. 63. pp. 192–205, 1898.) —This paper does not admit of a short abstract. W. R. C.

1145. *Deformations of Dielectric in Electric Field.* **P. Sacerdote.** (Comptes Rendus, 126. pp. 1019–1022, 1898.)—The unitary deformations undergone by a plate of dielectric substance are always proportional, if the temperature be kept constant, to the electric energy per unit of volume, $KH^2/8\pi$. The coefficients are (k_1+a) for the unit deformation perpendicular to the field, (k_2-a-2b) for that parallel to the field, and $\left(k+\frac{c}{3}\right)$ for the variation of volume per unit of volume; a and b being the coefficients of longitudinal expansion and transverse contraction, and c that of cubical compressibility, k_1 the coefficient of variation of K with traction perpendicular to the lines of force, k_2 that with traction parallel to them, and k that with uniform superficial traction. These k's are all small: if negligible, the result is that there is always contraction in the direction of the lines of force, lengthening transversely, and an increase of volume. A. D.

1146. *Dark Cross in Electromagnetic Radiation.* **J. C. Bose.** (Elect. Rev. 42. pp. 781–782, 1898.)—By interposing between polariser and analyser an artificial structure such as a disc made up by rolling a Morse strip of paper, or a disc of dried wood (transverse section), or a cylinder of cast ebonite rapidly chilled, the dark cross, as projected in space, can be mapped out by a detector. A. D.

1147. *Discharge in Rarefied Gases.* **W. Wien.** (Annal. Phys. Chem. 65. 2. pp. 440–452, 1898.)—Using Lenard's arrangement, the author proves that even in extreme vacua no limit is set to the capacity possessed by kathode rays of producing a negative charge in bodies upon which they impinge. Kathode rays are not deprived of this power by having to traverse a metallic window connected to earth. They are deflected even in a purely statical electric field. By compensating the electrostatic deflection by means of a magnetic deflection, the velocity of the particles may be determined. It is about one-third of the velocity of light, and the ratio of the mass of the particle to the charge carried by it is 5×10^{-8}. It may be proved that both the rays proceeding from the kathode and those proceeding from the anode contain negative charges, and similarly, that positive charges are conveyed by both kinds of rays. The conception of Goldstein's canal-rays may be generalised by saying that both electrodes emit charges of their proper signs from their front surfaces, and charges of the opposite sign from their back surfaces when perforated. E. E. F.

1148. *Mutual Influence of Parts of a Kathode.* **E. Wiedemann.** (Annal. Phys. Chem. 63. 1. pp. 246–252, 1897.)—By peculiarly shaping the parts of a kathode, deflections may be obtained in the kathode rays, analogous to those observed by Goldstein. A. D.

1149. *Action of Kathode Rays on Air.* **P. Lenard.** (Annal. Phys. Chem. 63. 1. pp. 253–260, 1897.)—Kathode and Röntgen rays differ in degree, not in their nature. Kathode rays discharge electrified charges, of either sign, at distances beyond those at which they can produce fluorescence (say 30 cm. as compared with 8); but this effect scarcely seemed to be due to kathode rays themselves, and was found to be due to electric conductivity imparted by them to the air, in much greater measure than that imparted by Röntgen rays of equal phosphorescence-producing power. Air acted upon by kathode rays also contains fog-nuclei in great abundance, much greater than that induced by Röntgen rays (Richarz) of equal phosphorescence-producing power.

A. Paulsen, Copenhagen, has a theory of the Aurora Borealis based on kathode rays: he anticipated in 1894 the fog-producing power of these rays, and showed that the auroral rays have this power.

A. D.

1150. *Rotation of Kathode Rays.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 368–371, 1898.)—A thin bundle of kathode rays impinges upon a fluorescent screen at the end of a vacuum-tube. A bar-magnet penetrates into the vacuum-tube through the fluorescent screen. It is protected by a glass tube. The kathode rays form a ring round the bar-magnet. The author asks whether this ring represents the impact of kathode rays which are in a state of rapid rotation round the pole. A stroboscopic examination shows no evidence of rotation. But that is not conclusive, as the rotation may be too rapid. The author therefore inserts a wire in the diaphragm through which the kathode rays pass. The effect of exciting the magnet is simply to displace the shadow of the wire in one sense or the other, according to the sign of the magnetising current. This argues against a rotation. The kathode rays behave as if they were flexible conductors fastened to definite points of the kathode, and tending to assume a minimum length. E. E. F.

1151. *Magnetic Action on Kathode and Röntgen Rays.* **A. Sandrucci.** (N. Cimento, 4. 7. pp. 112–120, 1898.)—The author gives an account of an exhaustive series of experiments, establishing for all cases the proposition that the kathode rays behave towards the ampere currents of magnets as rectilinear direct currents would do from the antikathode to the kathode. A vacuum-tube becoming worn by long use tends to reassume the characters of a fresh tube when put in a strong magnetic field whose lines of force are more or less athwart the current in the vacuum-tube. In the same sense even the terrestrial magnetic field acts, lengthening the life of the tube when its lines are at right angles to the tube, that is, when the tube is placed east and west. The magnetic action may hinder the discharge and then act in the same sense as if the tube itself were under a slightly lower vacuum. A. D.

1152. *Kathode Rays in Magnetic Fields.* **A. Broca.** (Comptes Rendus, 126. pp. 736–738, 1898.)—Description of experiments similar to and in continuation of those of Birkeland, on kathode rays in fields of varying intensity from zero to 15,000 C.G.S. The author concludes that there are two kinds of kathode rays,—those of the first sort which roll themselves round the lines of force of the magnetic field, and those of the second sort which follow these lines of force. One of these sorts arises suddenly for a certain value of the field and the rays commence by rolling themselves round the line of force, following a helix traced on a cylinder very slender and with very long step. J. J. S.

1153. *Multiple Resonance.* **L. Décombe.** (Comptes Rendus, 126. pp. 1027–1028, 1898.)—Photographs made with the aid of a rotating mirror and taken direct from a Hertz oscillator instead of from a secondary circuit show the oscillatory character of the discharge, and further that there is only one radiation of determinate period, which depends on the dimensions of the exciter and is the same throughout a spark-discharge. There is therefore no continuous spectrum of radiation; and multiple resonance can only be explained in the manner proposed by Poincaré (Archives de Genève, t. xxv. p. 609, 1891) and Bjerknes (Wied. Ann. xliv. p. 74: 1891), as a result of damping of oscillations. A. D.

1154. *Lecher's Apparatus.* **D. Mazzotto.** (N. Cimento, 4. 7. pp. 5–23, 1898.)—Further researches into the primary and secondary waves in Lecher's apparatus are described, from which it appears that the formulæ usually given are only applicable to the primary waves and to limiting cases of the secondary. The secondary waves are continuous with the primary; they are little influenced by the capacity of the condenser; the condenser-capacities have a maximum effect when they are symmetrically placed between the spark and the bridge; and it appears that they are produced when between the spark and the bridge there is produced one complete wave with a latent node between the condensers. A. D.

1155. *Temperature of Incandescent Lamps.* **P. Janet.** (Comptes Rendus, 126. pp. 734–736, 1898.)—With four 10-candle lamps taking 0·65 ampere, the temperatures, electrically measured, were 1620°, 1610°, 1630°, and 1720° respectively. A. D.

1156. *Alkalimetric Methods in Measuring Spark-Discharges.* **P. Cardani.** (N. Cimento, 4. 7. pp. 105–111, 1898.)—The author uses a solution of 1 part NaCl in 10 water, faintly coloured (the solution being invariably somewhat alkaline for this test) with phenolphthalein, and brought back by means of a few drops of N/200 oxalic-acid solution until the colour is a very pale rose. The electrolytic apparatus is such as to exclude the carbonic acid of the air. On passing spark-discharges the red colour due to caustic soda soon appears. Take this reddened solution and the original pale-rose solution; discharge the colour of the former with a N/200 solution of oxalic acid; add just as much N/200 solution of caustic soda as will bring this solution to the same tint as the pale-rose solution. The difference between these two quantities gives the quantity of caustic soda produced by the discharge. Dividing this by the number of sparks we get the quantity of soda liberated at each spark; and dividing the corresponding sodium by the electrochemical equivalent of sodium, we find the quantity of electricity discharged per spark. The numerical results work out with great exactitude. A. D.

1157. *Thermophones.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 358–360, 1898.)—The periodic changes of length or bulk produced by an oscillating current may be utilised for the electrical propagation of sound. The effect may be indefinitely increased by superimposing a steady current upon the variable current. A bolometer is inserted in the secondary circuit of a small induction-coil. As long as the secondary current alone traverses the bolometer, no sound is heard. But as soon as an independent constant current is made to traverse the bolometer, every impulse of the induced current produces a noise in the bolometer, which in this case acts like a telephone. The loudness increases with the strength of the steady current. On replacing the induction-coil by a microphone, nothing is heard. But even then, the sound may be brought out by Simon's sensitive arc. This is due to the strong steady current traversing the arc. If three or four secondary cells are put in circuit with a bolometer and a microphone, anything spoken into the latter is distinctly reproduced by the microphone. The bolometer may be replaced by strips of thin brass.
E. E. F.

1158. *Luminosity of Immersed Electrodes.* **F. Braun.** (Annal. Phys. Chem. 65. 2, pp. 361–364, 1898.)—Aluminium electrodes in an electrolytic cell charged by an alternating current emit over their whole surface a white or yellowish-red light, which changes into blue as the current becomes stronger. The phenomenon is best studied by means of a thin strip or wire of aluminium. This is viewed in a revolving mirror, together with the phosphorescent patch deflected by a magnet which is used by the author as an alternate-current indicator. The wire commences to glow at a very definite phase of the current which produces a development of hydrogen at the aluminium electrode, and ceases at a very definite phase of the vanishing current. The result is a sharply-defined intermittent patch of light in the rotating mirror, which may be utilised for the discrimination of current phases. Magnesium and zinc in Na_2S solution also show luminous effects, though feebler. E. E. F.

1159. *Determination of the Frequency of Alternating Currents.* **C. Kinsley.** (Phil. Mag. 45. pp. 339–347, 1898.)—The accurate determination of the frequency of alternating currents is often of importance. This has been found readily possible by the use of a telephone and a resonance-tube. It is suggested that the resonance-tube be of hard drawn brass, and that a dry piston be used to vary its length. The note given by the telephone in front of the tube, when operated by an alternating current from any commercial machine, will be a composite one whose fundamental has a periodicity equal to that of the alternator. It was found also that *all* of the harmonics, not merely the odd ones, were present up to a periodicity of at least 1200 per sec. Therefore, in order to determine the frequency of the alternating current it is merely necessary to get from the resonance-tube the frequencies of two successive harmonics. The greatest common divisor of these frequencies will then be the frequency of the alternating current. By means of tables the determination of frequency, from the length of the resonance-tube, becomes a very simple matter. As an illustration the following case is given:—

Let the diameter of the tube used be 5 cm. Temperature, 20° C.

From Table I.		From Table II.		
Observed length.	Correction for diam. = 5 cm.	Equivalent length.	Frequency at 20° C.	Frequency at 21° C.
l.	c.	ρ.	n.	n.
18 cm.	2·02	20	426·7	427·4
19 „	2·02	21	406·3	407·1
20 „	2·02	22	387·8	388·5
21 „	2·01	23	370·9	371·6
22 „	2·01	24	355·4	356·0

For one harmonic,

$$l=21{\cdot}68,\quad c=2{\cdot}02,\quad \rho=23{\cdot}70,\quad n=360{\cdot}00;$$

for the next harmonic,

$$l=18{\cdot}30,\quad c=2{\cdot}02,\quad \rho=20{\cdot}32,\quad n=420{\cdot}2.$$

The highest common divisor is 60·0, which therefore gives the frequency of the current: one of the above harmonics was the sixth and the next one the seventh. The method used in computing the table is explained and the constants used are given. The readings can be made more quickly and with less relative error than is found to be possible in many other electrical instruments—such as a Kelvin balance for instance: hence the use of this method for rapid and accurate measurements is quite possible. When it is desirable to get the actual periodicity as well as relative values, the above method can be readily used. It requires no difficult standardisation such as is necessary with the vibrating wire and rod methods. AUTHOR.

1160. *Measurement of Phase-Difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 353–361, 1898.)—The methods discussed refer to sine-currents only. The theory of two instruments—a split dynamometer and a rotating-field phase-meter—is worked out at length. A combination of these two into a single instrument is described, with some constructional details. A. H.

1161. *Graphic Registration of Phase-Difference.* **A. G. Rossi.** (N. Cimento, 4. 6. pp. 401–407, 1897.)—On the principle that the summation of two waves makes beat-waves, the amplitude of which is a sine function of the time, the author shows how to draw and interpret curves for the purpose of registering and ascertaining differences of phase between two practically sinusoidal currents. A. D.

1162. *Graphical Methods in Alternate-Current Problems.* **C. E. Guye.** (Écl. Électr. 15. pp. 363–369, 1898.) [See Abstracts Nos. 524 and 796].—The author considers the graphical solution of various problems involving combinations of resistances, inductances (self and mutual), and capacities. The use of *equivalent* resistances, etc., is explained: in the case of problems involving complicated networks of conductors, the introduction of such "equivalent" resistances, inductances, and capacities for a whole group of conductors, frequently results in a considerable simplification of the problem. [*To be continued.*] A. H.

1163. *Conductivity of Liquids in Thin Layers.* **G. B. Bryan.** (Phil. Mag. 45. pp. 253–270, 1898.)—Koller (Wien. Ber. 98. ii. *a.* p. 201, 1889) found that the specific resistance of some liquids, such as alcohol, turpentine, etc., increases as the thickness of the layer between the electrodes diminishes. The author reinvestigates the phenomenon. Measuring the resistance by a direct-current method, aniline gave numbers which varied with its purity, and were also affected by the length of time during which the current had passed, and to some extent by polarisation. The numbers obtained confirmed Koller's result. Using an alternating current, the thickness of the layer of electrolyte (0·175 to 10·17 mm.) has no effect on the specific resistance of aniline after the lapse of some hours, though when the apparatus is first put together the effect is noticed. With distilled water and alcohol the larger specific resistance of thin layers is again found, but is only apparent, the increase of resistance per unit increase of thickness being constant after the first thin layer. The discrepancy is therefore probably due to imperfections in the electrodes and their adjustment, and to polarisation. A more perfect apparatus and more rapidly alternating current being used, the specific resistance is found to be independent of the thickness of the layer of electrolyte. T. E.

1164. *Electrolytic Conductivity of Potassium Permanganate Solution.* **E. Legrand.** (Comptes Rendus, 126. pp. 1025–1027, 1898.)—The molecular conductivity increases with the dilution, and tends towards the limiting value 124 observed by preceding experimenters for neutral salts at 25°. It also increases with rise of temperature, the less rapidly the higher the temperature. A. D.

1165. *Hysteresis Losses.* **C. Maurain.** (Écl. Électr. 15. pp. 409–414, 1898.)—The method employed to determine the energy lost in a cycle is a modification of that used by J. and B. Hopkinson. An intermittent contact on the axis of an alternator enables the observer to find the difference of potential between the extremities of an inductionless resistance, R, forming part of the circuit, and between the extremities of the magnetising coil. The first is equal to Ri, i being the strength of the current at the moment considered, and the second is $ri+d\phi/dt$, r being the resistance of the coil, and ϕ the magnetic induction. The value of $d\phi/dt$ can thus be calculated, and a curve constructed, representing its variation in value during a period. An integration of the curves gives the value of the induction at any instant.

The author employs iron in the form of cores. There are five altogether; one is of solid iron with a circular section, and the others are made of iron wires of diameters 2·68, 1·57, 0·5, and 0·2 mm. respectively. He gives two series of curves with fields as abscissæ and inductions as ordinates, the frequencies being respectively 18·36 and 54·01. The curves, in general, show the well-known protective action, increasing with the frequency, of induced currents. With the solid iron they are of an oval shape, and they approach more and more to the curves obtained by what may be called the statical method (Ewing and others) with diminution of the diameter of the iron wire.

The author is inclined to the belief that his curves show a true retardation of the maximum induction behind the maximum current, *i. e.* a retardation which is independent of the currents induced in the core, and which is of the order of magnitude of 1/1000 of a second. He finds that the hysteresis loss in a cycle is practically independent of the frequency. A. Gs.

1166. *Magnetic Screening.* **H. du Bois.** (Annal. Phys. Chem. 65. 1. pp. 1–37, 1898.)—This paper contains Parts 2, 3, and 4 of what is practically a treatise on the subject of magnetic screening. The author has also published it in English in a series of papers in the 'Electrician' (see Abstract No. 954). J. B. H.

1167. *Tangential Magnetic Screening Action.* **H. du Bois.** (Annal. Phys. Chem. 65. 2. pp. 403–407, 1898.)—The case of magnetic screening usually investigated consists in the enfeebling of magnetic lines of force impinging vertically, or nearly so, upon the screening surface. But many electricians have assumed, in addition, the existence of a screening action against lines of force running parallel to the surface of the screening substance, as in the case of a cylinder surrounded by concentric lines of force. The simplest case is that of a hollow toroid of some magnetic substance. Two cases may be distinguished. The first case, that of interior tangential screening, takes place when the magnetising coil lies in circles concentric with the toroid on its outer surface. The second case, that of exterior screening, when the magnetising current flows through the centre of the generating circle of the toroid. Kirstädter failed to find a trace of the former, whereas the exterior action was alleged to have been observed by W. v. Siemens. The author attributes the alleged screening to a dispersion of the lines of force in the equatorial section of the toroid, and to other sources of error. He believes that tangential screening effects are absent even in hard steel. E. E. F.

1168. *Magnetisation.* **P. Morin.** (Écl. Électr. 15. pp. 154–166, 1898.)—The mean intensity of magnetisation increases very rapidly with the length of the bar (magnetised to saturation), at first more rapidly than the length, then more slowly, and tends to a maximum value. In long magnets of different lengths, the only difference is in the length of the central region of uniform magnetisation: the terminal regions are identically similar. A magnet of about 50 diameters length has no central region of uniform magnetisation; and each terminal region is then 25 diameters long. The equivalent ideal magnet would be about 30·5 diameters long; and therefore the free magnetisation is more towards the ends of the uniform central region than towards the extremities of the magnet. In each terminal region the magnetisation increases with increasing rapidity from the extremity towards the midpoint of the magnet; and it reaches a maximum which is the magnetisation of the central uniform region of the magnet. When the magnets are shorter than twice the length of one such terminal region, the magnetisations starting from the extremities are the same as before, but a corresponding part of each terminal region is cut out. Consequently, since the curves are flattest at the ends of the magnet, the ideal uniform magnet is more nearly attained the shorter the magnet; and the relative length of the corresponding ideal magnet is greater the shorter the actual magnet. These results are confirmed, with merely numerical differences, by a long series of experiments; and they are not in disaccord with those of Coulomb and Bouty, which were mostly obtained from magnets long enough to present a central uniform region. Precisely similar results are obtained by building up a magnet out of magnetised steel wires. Therefore, if we consider the magnet as made up of filaments one molecule thick, each such filament would have its terminal region not more than 25 molecules long. Also, since the terminal magnetisation after saturation is independent of the length of a magnet, and depends only on the metal and the area of cross-section, the same would apply to magnetised discs one molecule thick. There will thus in the case of saturation in ordinary space be two maxima, a terminal-face maximum, and a central-portion maximum. Both these maxima will be higher in an exterior magnetic field, but in this case both again reach a superior limit; and both return to their former value when this is abolished. When a filament is more than two molecules long the intermediate molecules are in the magnetic field of the others,

and four molecules have more than four times the magnetic moment of a single molecule; and so on for greater numbers; and the free magnetisation will go on increasing as we travel from the extremity towards the centre, until a limit is reached which is uniform throughout the central region. In a magnetised disc made up of two parallel molecules the molecules tend to demagnetise one another; an additional molecule tends to be demagnetised by both, and so for greater numbers, a limit being reached with a maximum of intensity at the edges, which maximum is, however, less than that at the extremity of a single magnetic filament. By synthesising such magnetic filaments or discs we arrive, for real magnets, at distributions such as those investigated.
A. D.

1169. *Elongation during Magnetisation.* **G. Klingenberg.** (Journ. de Physique, 7. pp. 287–288, 1898.)—There is a close parallelism between the elongation in a bar of steel or iron and the magnetisation: the curves are similar, both tending towards a maximum; the residual phenomena are similar, but greater in steel; shocks reduce hysteretic and residual phenomena for both elongation and magnetisation. Residual elongation diminishes as the traction increases. A. D.

1170. *Susceptibility of Diamagnetic and Weakly Magnetic Substances.* **A. P. Wills.** (Phil. Mag. 45. pp. 432–447, 1898.)—The author describes a new and very simple method for discovering the coefficients of magnetic susceptibility or permeability; the method being applicable to Solids, Liquids, and Gases; results, however, being given for Solids only.—A very powerful magnetic field is secured by means of a large electromagnet; the prismatic shaped pole-pieces of this magnet are so placed that their plane faces are directly opposite each other and separated by a distance of 1·5 cm. These pole-faces are rectangular in shape, and of dimensions 8 cm. by 1·5 cm., the long edges being horizontal. Between these pole-faces is obtained a practically uniform field of great strength. Slabs are prepared of the substance for which the coefficients are required. These have approximately the dimensions 8 cm. by 4·5 cm. by ·5 cm.

In making an experiment a slab is suspended by means of a long wire from one end of the beam of a very sensitive balance in such a way that the long edges of the slab are vertical, the medium edges parallel to the long edges of the pole-faces, and the short edges perpendicular to the same. The bottom surface of the slab is made to lie in the horizontal plane of symmetry of the two pole-pieces, and the slab is in every other way symmetrically placed in respect to them. Thus the bottom surface is in a very strong magnetic field, while the top surface of the slab is in a comparatively weak field. So placed, the substance experiences a mechanical force in the vertical direction only; for by symmetry the mechanical forces in the other directions annihilate each other. The total mechanical force in the vertical direction and measured by the balance is given by

$$P = \frac{\kappa A}{2g}(H^2 - H'^2),$$

where P is the force, κ the required coefficient, A the area of the horizontal section of the slab, H the magnetic force at the bottom surface of the slab, H′ that at the top surface, and g is the known acceleration due to gravity. Experiment shows H'^2 in comparison with H^2 to be negligible. We have then for κ:

$$\kappa = \frac{2gP}{AH^2}.$$

H is found by measuring the force of the field upon a conductor in it carrying a known current. The same balance mentioned above is used for this purpose.

The coefficients for many substances are given in the original paper. The values of $\kappa \times 10^6$ for bismuth, glass, marble, wax, and shellac were found respectively to be $-12{\cdot}55$, $-{\cdot}578$, $-{\cdot}832$, $-{\cdot}560$, and $-{\cdot}394$.

Experiments upon bismuth and wax showed that within wide limits the strength of the field used had no effect as regards a change in the value of κ. AUTHOR.

1171. *Effect of Soft Iron on High Frequency Currents.* **H. Pellat.** (Comptes Rendus, 126. pp. 731–733, 1898.)—An oscillatory current of high frequency is obtained in a coil B by the ordinary method, on joining the extremities of the wire to the outer coatings of two small Leyden jars, whose inside coatings communicate with the poles of a Ruhmkorff coil. The knobs of these jars are sufficiently close together for a spark to pass between them at each oscillation of the contact-breaker. When the frequency of the oscillatory current (obtained from the knowledge of the capacities and of the coefficient of self-induction of B) is 300,000, if a second coil B′ with a layer of fine wire is introduced into the axis of the coil B, sparks of 6 mm. to 7 mm. are obtained between the extremities of the wire of this coil. This is Tesla's arrangement. If then the coil B′ is put outside the coil B so that the axes coincide, the E.M.F. of induction is too small to produce a spark between the extremities of the wire of B′. On placing in the interior of the two coils a bundle of wires of soft iron (0·25 mm. diam.), the spark is no more produced.

This negative experiment might appear to show that iron is not magnetised in a magnetic field alternating with high frequency; but another experiment proves that iron is magnetised in these conditions, and that its magnetisation may have a considerable influence on certain phenomena.

The coil B′ being taken away, the extremities of the wire of the coil B still joined to the outside coatings of the Leyden jar are put in relation with the two plates of a very sensitive balance-electrometer, the displacement of the movable plate being observed by means of a microscope with cross-wires. When the apparatus is in action, the movable plate is displaced under the influence of an electric force proportional to the mean square U of the difference of potential between the extremities of the coil B

$$\left(U=\int_0^1 V^2 dt\right).$$

But the author has shown that the introduction into the coil B of a bundle of wire, similar to that used in the above experiment, diminishes considerably the value of U. This effect is not due to Foucault currents, for copper wires or masses of brass produce only an insignificant diminution of U. The same result has been obtained with three different coils. In one case in which the number of periods was 298,000, the value of U, although very small, corresponded to a displacement of the plate of which the $\frac{1}{50}$ part could be appreciated; bundle of soft iron reduced the value of U in the ratio of 3 to 1. The introduction of the iron causes a marked change in the noise of the sparks passing between the knobs of the Leyden jars.

These experiments show that the presence of even a small quantity of iron in the axis of a coil prohibits the use of the classical formula

$$\frac{d(Li)}{dt}+Ri+V=0 \quad \left(\text{with } i=C\frac{dV}{dt}\right),$$

for obtaining the value i by the oscillating current, considering the self-induction L as constant.

This formula leads in fact, for the value of the mean square of the potential difference U, in the case of L constant, to the expression

$$U=n\frac{V_0^2 L}{2R},$$

in which n is the number of interruptions per sec., V_0 the P.D. between the knobs of the Leydens when the spark is going to pass, and R the resistance of the coil B. But L considered as a constant increases by the presence of the iron in the coil, which ought, according to the formula above, to increase U, whilst experiment indicates a considerable diminution. This phenomenon must be considered as due to hysteresis, of which the above relation takes no account if L is considered constant: the flux of induction due to the iron has a retardation of phase on that due to the current alone, and a part of the energy of this current is transformed into heat-energy in the soft iron. J. J. S.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1172. *Atomic Weights.* **D. Berthelot.** (Comptes Rendus, 126. pp. 954, 1030–1033, & 1415–1418, 1898.)—The molecular weight of a gas is proportional to its limiting density, under an infinitely small pressure. The limiting density is equal to the product of its normal density at 0° C. and atm. pr. into $(1-\epsilon)$, where ϵ is the departure of the compressibility of the gas from Boyle's law, between 0 atm. and 1 atm. at 0° C.; that is, according to Regnault,

$$\epsilon = 1 - \frac{p_0 v_0}{pv} = \mathrm{A}_p^{p_0}(p_0 - p),$$

where p_0, v_0 are the normal pressure and the corresponding volume, p, v the observed pressure and volume, and A the mean compressibility between p and p_0. If $p=0$, the expression becomes $\epsilon=\mathrm{A}_0^1$, and the molecular weight is proportional to $\left(1-\mathrm{A}_0^1\right)d$. It remains therefore to find A_0^1. For permanent gases we may justly assume this to be the same between 0 atm. and 1 atm. as it is between 1 atm. and 2 atm.; for liquefiable gases, more calculation is necessary.

From the observed densities and compressibilities ensue the following:—

	H.	N.	CO.	O.
Molecular volume at 0° and atm. pr.	1·00046	0·99962	0·99954	0·99924
Molecular weight	2·01472	28·0132	28·0068	32
Atomic weights (O=16)	1·0074	14·007	[C=12·007]	16

The molecular volume of hydrogen is greater than that of a perfect gas, hydrogen being less compressible at 0° C. than Boyle's law would indicate. The maximum error in the atomic weights is $\pm\frac{1}{5000}$ of their values. The chemical results run for oxygen from 15·866 to 15·897 (H=1), and the value 15·880 is now accepted. M. Leduc's very exact working gives 15·881, or for O=16, H=1·0075. Syntheses of CO_2 from diamond or graphite give C=11·998 Dumas and Stas, 12·009 Erdmann and Marchand, 12·004 Stas (CO_2 from CO), 12·003 Roscoe, 12·011 Friedel, 12·001 to 12·005 Van der Plaats. The chemical methods for nitrogen are roundabout and unsatisfactory: Stas 14·044; Thomsen's data, 14·019; Hill's data (Amer. Chem. Journ. 1896), 14·012. M. Leduc, from the relative densities of CO and N in corresponding states, finds 14·005.

For liquefiable gases, the following are the results of the data of

Leduc, Amagat, and Sacerdote and Mathias' table in the *Annuaire du Bureau des Longitudes* :—

	O.	CO_2.	N_2O.	HCl.	C_2H_2.	PH_3.	SO_2.
Normal densities (O=1) ...	1	1·38324	1·38450	1·14836	0·81938	1·07172	2·04835
Compressibilities between 1 atm. and 2 atms.	0·000760	0·006916	0·007828	0·008132	0·008664	0·009707	0·025992
Critical temperatures	−118° C.	31°·35	36°	52°	37°	52°·8	156°
Constant α in Van der Waals' formula......	0·001588	0·009131	0·010244	0·010442	0·011278	0·012359	0·028544
Constant β in Van der Waals formula............	0·000828	0·002427	0·002682	0·002599	0·002943	0·003069	0·005384
Mean compressibility between 0 and 1 atm.	0·00076	0·00674	0·00761	0·00790	0·00840	0·00937	0·02368
Molecular volume at 0° C. and atm. pr.	0·99924	0·99326	0·99239	0·99210	0·99160	0·99063	0·97632
Molecular weight (O=32)	32	44·000	44·000	36·486	26·020	34·001	64·046

From these values it will be afterwards shown that the atomic weights of carbon, nitrogen, chlorine, phosphorus, and sulphur can be determined as precisely as, and in some cases more precisely than, by chemical methods. A. D.

1173. *Photo-electric Relations of Coloured Salts.* **J. Elster** and **H. Geitel.** (Annal. Phys. Chem. 62. 4. pp. 599–602, 1897.)—Just as chloride of sodium and other salts which have become coloured through exposure to kathode rays have their colour discharged by exposure to sunlight or daylight, so do these salts when they have acquired similar colours through exposure to potassium or sodium vapour. When coloured with a trace of Prussian blue they do not. Everything points towards these coloured products being solutions of traces of the metal in the solid salts. A. D.

1174. *Lecture Experiments.* **Küster.** (Zeitschr. Elektrochem. 4. pp. 503–505, 1898.)—Some lecture experiments are given illustrating the connection between the electrochemical theory of potential difference and certain facts of analytical chemistry. (See Phys. Soc. Abstracts, Nos. 104 & 217, 1897.) B. B. T.

1175. *Relations between Luminous and Chemical Energy.* **Berthelot.** (Comptes Rendus, 127. pp. 143–160, 1898. See also Comptes Rendus, 127. p. 84.)—This series of experiments were conducted at the ordinary temperature under (1) direct sunlight, (2) diffused daylight, (3) darkness; also with interposition of various liquids and solutions; with a duration of weeks or months.—*Nitric acid* and nitric anhydride, when pure, underwent no decomposition in the dark. But the former, under protracted exposure to solar light, gave amounts of oxygen corresponding to from 12 to 42 per cent. of the total transformation $2HNO_3 = 2NO_2 + O + H_2O$, free nitrogen and nitrous oxide being absent. The effects of light are parallel to those of heat, but produced at a lower temperature. Diluted nitric acid (1·365 sp. gr.) was found to be practically stable in solar light, probably because the layers of NO_2 which might be formed tended to absorb the actinic rays. A solution of potassium dichromate completely arrested the effective solar radiation, whereas ammonio-sulphate of copper in fairly thick layers did not.

Numerous trials were made with chloride of silver, hydriodic acid, and other bodies affected by light, which showed that the changes, as in the case of heat, were reversible under exothermic or endothermic conditions. Copious details of the experiments are given in the original paper. S. R.

1176. *Heat evolved on Wetting Powders.* **T. Martini.** (Rivista Scientifica, 30. pp. 131–132, 1898.)—Anhydrous silicic acid rises 29° C. with water, 32° with ethyl-alcohol. The production of heat is proportional to the quantity of powder used. (Meissner denied this.) A. D.

1177. *Heat of Solution, Solubility, and Freezing-point.* **A. Dahms.** (Annal. Phys. Chem. 64. 3. pp. 507–518, 1898.)—This paper contains an attempt at finding the relation between lowering of freezing-point and concentration for solutions not dilute, in two cases of complete heterogeneous equilibrium, *i. e.* equilibrium between a solution of a non-volatile salt, the salt itself, and the vapour of the solvent, and the equilibrium between two solids and a eutectic mixture of them. Based on a thermodynamic equation quoted from Planck, the author finds that if C_1 C_2 are the concentrations (*i. e.* fractional composition) of the two components of the liquid mixture, θ θ' the absolute temperatures, and r_1 r_2 the latent heats of solution of the two substances (*i. e.* heat absorbed in removing 1 gm.-mol. of each isothermal-isopiestically from an infinite quantity of solution),

$$\frac{d \log C_1}{d\theta} : \frac{d \log C_2}{d\theta'} = r_1 : r_2.$$

The theoretical part is followed by a number of illustrations, in which (i) the heat of separation of NaCl from its saturated solution is calculated from the concentration and the latent heat of water; (ii) the composition of a eutectic mixture of nitrobenzene and ethylene bromide is compared with that found from the latent heats; (iii) it is shown that the formula leads to correct results for the variation in the solubility of naphthalene and ethylene dibromide, diphenylamine in ethylene dibromide, and other cases. R. A. L.

1178. *Solubility of Iodine in Mixed Liquids.* **L. Bruner.** (Zeitschr. Phys. Chem. 26. pp. 146–151, 1898.)—Determinations are given of the solubility of iodine at the ordinary temperature in mixtures of benzene, chloroform, carbon tetrachloride, carbon bisulphide, ethyl and *n*-propyl alcohols and water. For each pair of liquids, mixtures containing from 0 % to 100 % of the constituents are investigated. Mixtures of a concentrated solution of potassium iodide and water are also used. The quantity of iodine dissolved by a mixture is always smaller than the quantity which the constituents of the mixture would dissolve if separate. The differences are largest in the mixtures containing the alcohols.

T. E.

1179. *Chemical Statics.* **P. Duhem.** (Journ. Phys. Chem. 2. pp. 1–42 & 91–115, 1898.)—This paper is a commentary on and a supplement of Gibbs' memoir. The phase-rule is demonstrated without any assumption that the independently variable components of each of the phases of a system are identical with the independently variable components of the system as a whole. The subjects treated comprise:—(1) The thermodynamic potential of a homogeneous mixture; (2) General theorems of the chemical statics of homogeneous systems; (3) General principles of the chemical statics of heterogeneous systems (α) maintained under a given pressure, (β) at constant volume; and the final conclusion is that every true chemical equilibrium of a system maintained at constant temperature and pressure, or at constant temperature and total volume, is either stable or indifferent. R. E. B.

1180. *Three-Component System.* **H. R. Carveth.** (Journ. Phys. Chem. 2. pp. 209–228, 1898.)—Lithium, sodium, and potassium nitrates were chosen for this system, as (1) they dissolve without decomposition to a homogeneous solution, (2) they form neither solid solutions, mixed crystals, nor double salts, (3) their respective melting-points do not lie far apart: they consequently form the simplest triple system possible. The observations were plotted on a triangular diagram, the points of which we may denote by L, N, K. The isothermals have only a single branch across the K corner for temperatures between 337° and 308°, the fusing-points respectively of KNO_3 and $NaNO_3$; down to 253°, the fusing-point of $LiNO_3$, they have two branches, across the K and N corners respectively; for lower temperatures they have three branches. There is a binary eutectic point on KN for 218°, another on NL for 204°, and a third on NK for 129°: thus, above 218° the branches are all separate, down to 204° two of them only are connected, and below this all three are connected, though they do not form closed curves till 129°. At 119°, the fusing-point of the ternary eutectic, the three branches close into a single point. The points of connection of the several branches lie on lines joining the ternary eutectic point to the three binary eutectic points which separate the fields in which the several salts occur as solid.

The application to these solutions of the freezing-point method was then considered, but without definite result, possibly because of their great concentrations; and the employment of the triangular diagram in metallurgy, in the examination of alloys, and in other ways was suggested. R. E. B.

1181. *Estimation of Ionisation-Constants by Increase of Solubility.* **R. Löwenherz.** (Zeitschr. Phys. Chem. 25. pp. 385–418, 1898.)—The solubility of an acid is increased on adding a base by the amount of undissociated salt (SB) and the increase of acid ions (dS'). Where the acid is weak the concentration of H′ ions will be small, as also that of OH′ ions (which may be calculated from the equation $H' \times OH' = K^2$, where K is the ionisation-constant for water, $1{\cdot}14 \times 10^{-7}$ at 25°). Since $H' + S' = B' + OH'$, we have B′ nearly equal to S′, and the ionisation may be assumed, without serious error, equal to that in a solution of SB (or of LiCl) of the concentration $SB + S'$: this enables SB to be calculated from the increase of solubility, and hence S′ and B′. H′ is calculated from the equation $k \times SH = S' + H'$, where the product $k \times SH$ is constant and is determined in solution of the acid in pure water. The amount of base unaccounted for exists free as BOH. The ionisation-constant of the base can now be calculated as $B' \times OH'/BOH$. The method applies inversely to acids also.

The method is applied to aniline and *p*-toluidine with cinnamic and *p*-nitrobenzoic acids, giving values agreeing well together and with those of Bredig (Zeitschr. Phys. Chem. 13. p. 321) calculated by his own and by a new method. By choice of acids (or bases) of suitable strength and solubility, constants can be estimated down to 10^{-14}. A number of results are given. B. B. T.

1182. *Inter-relation of Equilibrium Constants in different Solvents.* **B. Kuriloff.** (Zeitschr. Phys. Chem. 25. pp. 419–440, 1898.)—The author tests the equation $K_2 = K_1 k_1 / k_2 k_3$, where K_1 and K_2 are the equilibrium-constants of the reaction

$$\beta\text{-Naphthol picrate} \rightleftarrows \text{Picric acid} + \beta\text{-Naphthol}$$

in benzene and water, and k_1 k_2 and k_3 are the partition-coefficients of the three substances, by determining K_1 K_2 k_2 and k_3, calculating k_1, multiplying by the solubility of β-naphthol picrate in benzene, and comparing with the observed solubility in water. The β-naphthol is estimated by Küster's method with iodine and thiosulphate, according to an empirical table. K_1, determined from the solubility of β-naphthol picrate in benzene on addition of known quantities of one component, varies from 0·63 to 0·84. k_2, allowing for the electrolytic dissociation calculated from Ostwald and Bredig's measurements, is 37 to 42; this is confirmed by observing the alteration of relative solubility on adding sodium picrate, the degree of dissociation of which is known. k_s is 63 to 73. The solubility of β-naphthol picrate in benzene is 3030×10^{-6} gram-mols. per litre, whence the solubility in water should be $4{\cdot}7 \times 10^{-6}$. This value is determined, first by the difference of solubility of picric acid on adding excess of the picrate; secondly by the difference in solubility of β-naphthol under the same circumstances; and thirdly by correcting the directly observed solubility of the picrate for dissociation, according to the equilibrium constant determined from the alteration of solubility on adding known quantities of one component. The first method agrees with calculation in showing a very small difference in solubility; the second and third methods give 7·9 and $8{\cdot}9 \times 10^{-6}$. All data are for 29°·5 C. Consideration of the composition of the saturated solutions in benzene and water with varying proportions of picric acid and β-naphthol show that both systems belong to Roozeboom's second type, where two substances form a compound whose melting-point (point at which solid and liquid phases have the same composition) lies between two quadruple points; but if the electrolytic dissociation is not taken into consideration, the aqueous system appears to be of the third type, where the melting-point cannot be reached, owing to previous separation of another solid phase. B. B. T.

1183. *Viscosity of Solutions of Electrolytes.* **H. Euler.** (Zeitschr. Phys. Chem. 25. pp. 536–542, 1898.)—Arrhenius has shown that the viscosity, H, of a solution containing two salts whose concentrations are respectively x and y, may be represented by

$$H = A^x B^y,$$

A and B being viscosity coefficients depending on the nature of the salts. The author assumes that the ions and undissociated molecules in the solution of a single salt may be treated as separate substances, each with its own viscosity coefficient, and writes for the normal solution of a salt

$$H = S^{(1-\alpha)} A^{\alpha} K^{\alpha};$$

where S, A, and K are the viscosity coefficients of the undissociated molecules, anions, and kathions, and α is the degree of dissociation. Ions of equal mobility influence the viscosity of water to the same extent; it is therefore plausible to assume that they have equal viscosity coefficients. By means of this hypothesis and measurements of the viscosity of solutions of different concentration, the values of A and K for a series of ions are calculated. The connection between the mobilities of the ions (U) and these viscosity coefficients (A) is shown in the following table (for normal solutions at 25°):—

	U.	A−0·68.	(A−0·68)U.
Li ……	39·8	0·47	18·7
Na ……	49·2	0·411	20·2
Mg ……	58	0·368	21·3
Ag ……	59	0·379	22·4
Cu ……	59	0·356	21·0
Ca ……	62	0·348	21·6
Sr ……	63	0·337	21·2
Ba ……	64	0·323	20·7
Cl ……	70·2	0·282	19·8
NH_4 ……	70·4	0·283	19·9
K ……	70·6	0·282	19·9
Br ……	73·0	0·266	19·4
Rb ……	73·5	0·278	20·4
Cs ……	73·6	0·269	19·8

The number 0·68 would represent the viscosity coefficient of an infinitely mobile ion. The values for H and OH are quite exceptional, the product (A−0·68)U having the value 126·7 for H and 78·5 for OH.

That some salts diminish the viscosity of water is due to the compression of the water by the attraction between the charges on the ions. This diminution of viscosity may exceed the increase due to the presence of the dissolved ions or molecules.

T. E.

1184. *Separation of Cobalt and Nickel.* **Coehn.** (Zeitschr. Elektrochem. 4. pp. 501–503, 1898.)—From experiments on electrostenolysis the author found that cobalt deposits superoxide at the anode, while nickel does not. This is found to furnish a method of quantitative separation. To prevent deposition at the kathode, a solution of a more easily separable metal (copper) is added.

B. B. T.

1185. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 31–39, 52–58, 72–76, 1898.)—This is a short historical sketch of the results of electrolysing solutions of various groups of organic substances, followed by an account of the action of (nascent) electrolytic oxygen on certain organic substances which are not themselves capable of being broken up into ions.

W. G. M.

GENERAL ELECTRICAL ENGINEERING.

1186. *Earth-Plates.* (Archiv. Post. Tele. 3. pp. 69–75, 1898.) —This paper is a description of experiments commenced in 1892 by the Telegraphen-Ingenieur Bureau on the various forms of earth-plates in common use. A piece of ground of uniform nature was selected, the water-level being 2·60 m. below the surface. The following forms of earth-plates were laid down, both below and above the water-level:—Iron and copper tubes, both bare and tinned, lead tube, copper sheet and copper wire-netting; also iron tube and copper wire-netting embedded in coke. Between 1892 and August 1897, 27 measurements were made of the resistances offered by these earth-plates. Those laid below the water-level showed far less variation in resistance than those above. The smallest resistance was that of the tubes, 3 m. long by 102 mm. diameter, driven in till the upper ends were 4 m. below the ground-level; its value varied between 5 and 11 ohms. The material seems to play no important part, and in no case was any regular change in resistance with time observable. The copper sheets and netting, laid horizontally 3 m. below the surface, had a higher resistance of about 16 ohms. A very great difference was found to exist between earth-plates laid in coke and those in earth. An iron tube laid horizontally 2 mm. below the surface gave 111 ohms as its mean resistance; a similar tube in coke gave 13. Corresponding values for copper netting similarly laid were 51 and 26 ohms. To further test the use of coke for earth-plates, a number of coke masses were laid down, of varying size, but all with their central plane 1 m. below the surface. In these were embedded iron tubes vertically, and copper netting horizontally. Coke in lumps gave better results than in the form of fine ash. Up to a certain point only, the size of the electrodes is of influence: thus copper netting of one-sixteenth of a square metre in area gave 28 ohms, while netting one-quarter of a square metre showed about the same resistance as that one square metre in area, viz. 23 ohms.

Where wet earth cannot be reached the best earth appears to consist of an iron cable laid in a mass of lump coke, the two ends being brought out and connected together. Experiments made in different localities show that the nature of the ground, *i. e.* whether exposed to sun or wind, or in a shady, protected position, has far more influence on the resistance than the nature of the earth-plate. As the earth-plates laid down in 1892 have not yet been taken up, the discussion on the relative durability of the different materials is reserved for a later paper. G. H. Ba.

1187. *Tournaire Electric Call-Indicator.* **L. Montillot.** (Électricien, 15. pp. 308–311, 1898.)—A short account is given of an indicator devised by C. Tournaire, which contains neither springs nor permanent magnets; the indicator is primarily intended for use with electric bells, but several modifications to suit special cases are described. A. H. A.

1188. *Electric Meters for Differential Rates.* **M. O'Gorman.** (Lightning, 13. p. 486, 1898.)—The price of current is varied daily in a wave proportional to the load-curve by means of a cam whose profile is determined from the station load-curve and plotted in polar coordinates. E. H. C.-H.

1189. *Improved Aron Meter.* (Elekt. Runds. 15. pp. 142–144, 1898.)—This meter comprises a fixed series-coil and a shunt-coil mounted on a vertical axis so that its period of oscillation shall vary as the square root of EC. This pendulum is actuated by a clockwork train, which may be termed the "main" movement. A uniformly running train, termed the "auxiliary" movement, is also employed, together with a counting-train. Since the number of oscillations of the anchor of the main movement varies as $\sqrt{EC}$, it is necessary, in order to read off the watt-hours directly, to employ some mechanical means of quadrature. The following is the theory of the method employed, viz.:—The main movement, in unit time, makes $n=c\sqrt{EC}$ oscillations. Therefore the time of one oscillation $1/n=1/c\sqrt{EC}$. After every m oscillations of the main movement, the auxiliary movement is thrown into action, the periodic time of which is $T=m/n$ or $T=m/c\sqrt{EC}$; the number of cycles or periods in unit time is thus $N=1/T=c\sqrt{EC}/m$. During each cycle the auxiliary movement couples the main movement with the counting-train during a definite time t, smaller than T. In the time t the main movement makes nt oscillations and communicates these to the counting-train, and since there are N cycles in unit time, the advance of the counting-train in unit time $Z=nt N$ oscillations. If now values be inserted for n and N, we have $Z=c^2 t EC/m$, wherein $t\ c\ m$ are constants; thus the indications of the counting-train are proportional to EC, *i. e.* it indicates watt-hours.

The main and auxiliary movements are driven from a common mainspring through differential gear, so as to work independently of each other. The main movement consists of an escapement-wheel, an anchor, and a third-wheel. The anchor is provided with a toothed-segment gearing with a bevel-wheel on a vertical arbor carrying the movable coils of the meter so that, as the toothed segment oscillates, the coils turn through a suitable angle in opposite directions alternately, this angle being greater than that through which the anchor moves. The current passes to the movable coils through weak spiral springs. The auxiliary movement consists of a third-wheel, an escapement-wheel, and an anchor controlled by a small pendulum. On the arbor of the third-wheel of this movement is a wheel having notches in its periphery corresponding in number to the ratio of the number of teeth in the third-wheel to that in the pinion on the arbor of the escapement-wheel; for example, eight. This acts to couple the main movement to the counting-train by means of a pivoted double-armed lever, one arm of which is provided with a pin for engaging with the periphery of the notched-wheel above mentioned, whilst the other arm bears an arbor having two gear-wheels on it. These gear-wheels, when the pin is resting on an unnotched part of the periphery of the notched wheel, engage respectively with a gear-wheel on the arbor of the escapement-wheel of the main movement, and with a gear-wheel forming part of the counting-train. When the pin is in a notch in the notched wheel, the counting-train is disconnected from the main movement. On the escapement-wheel of the auxiliary movement are two pins which only permit a single revolution of the escapement-wheel for each release. The lower pin lies normally against an arm of a pivoted double-armed lever, the second arm of which is acted upon by a pin on the third-wheel of the main movement. When this second arm is actuated by the main movement, the lower pin on the escapement-wheel of the auxiliary movement slides past the first arm and the upper pin comes to rest against it. When the lever moves back again, the second pin is released and the escapement-wheel of the auxiliary movement can rotate freely through one revolution, after which the lower pin again engages with the first arm of the lever. Since the third-wheel of the main movement is provided with four pins, the number N of periods for throwing the auxiliary movement into and out of gear is four times the number of revolutions of the third-wheel of the main movement in unit time, whilst the time that the auxiliary movement is in gear is that of one revolution of the escapement-wheel of the auxiliary movement. The time that the counting-train is in gear is determined by the length of the unnotched parts of the periphery of the disc on the escapement-wheel of the auxiliary movement.

C. K. F.

1190. *Electrical Carbonisation of Filaments.* **L. S. Powell.** (Elect. Rev. 42. pp. 646–648, 1898.)—The author discusses the advantages which may be obtained by carbonising glow-lamp filaments by electricity, and describes some experiments which he has made in this direction. In these experiments brick troughs were constructed on a brick platform covered with a layer of slag-wool. In one experiment the troughs, which were about a metre long, were first provided with a layer of plumbago powder, sprinkled with paraffin, and then packed with carbon blocks on which the cellulose threads were wound, the spaces being filled up with tightly compressed plumbago powder. The current entered and left the troughs by stout terminal plates of carbon. The upper surface of the troughs was covered by slabs of earthenware, and the whole surrounded by a thick coat of slag-wool. Thec urrent through the troughs at starting was about 18 to 19 amperes, and by gradually cutting out resistance was increased to 30 amperes in 10 hours, and to 65 amperes in 17 hours, at which point it was interrupted. After a lapse of 6½ hours, the current was again started at 27 amperes; in 6 hours' time it again reached 65 amperes, and was then apparently stopped. The majority of the filaments obtained were satisfactory in every respect, their flexibility and "colour" being good, whilst their resistance cold remained practically steady both before and after raising to incandescence in an inert gas. Suggestions are also given as to how the apparatus could be improved. C. K. F.

1191. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 15. pp. 228–233, 1898.)—This is an illustrated description of the electric furnaces of Hughes, Contrado, Regnoli, Siemens and Halske, Horry, Chalmot, Patten, and Strong. W. G. R.

1192. *Switchboard Apparatus.* **J. R. Blaikie.** (Electrician, 41. pp. 209–213, 1898.)—The author endeavours to point out the lack of uniformity among switchboards of existing central stations, and urges the advantages to be gained by combining the best features and standardising switchboards. He appeals to those designing stations to carefully consider the situation and room allowed in the buildings, and also to make the requirements of the supply conform as far as possible to the use of a standard board. He also touches on the subject of establishing a recognised code of engine-room signals from the switchboard.

With these objects in view he criticises the details of switches, instruments, rheostats, etc. commonly in use, and suggests a list of the breaking distances for various pressures and currents, which may be considered as safe under usual circumstances. Criticising boards as a whole, the fire risk is the most largely dealt with, assuming that general convenience and the reliability of each detail is approved. The position of rheostats is then discussed: it is advantageous to place the rheostat on the machine it is intended to govern, but it is also an advantage to use the waste heat from rheostats to keep the board at a higher temperature than the air, thereby avoiding leakage troubles by preventing a deposit of moisture on the surface of the board. The author strongly recommends the prevention of fire by eliminating the cause, rather than the plan adopted by some of abolishing all inflammable material. The use of wood is often convenient for protecting the attendant from "earthed" structures and adds to the appearance of the switchboard. With reference to engine-room signals, several methods are described and criticised. Author.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1193. *Insulation of Armature Bolts.* **P. Boucherot.** (Ind. Élect. 7. pp. 177–180, 1898.)—The author states that nine out of ten of the French manufacturers of dynamos insulate the bolts traversing the iron laminations of dynamo armatures, while of Swiss constructors only 1 in 10 take this precaution. He then proceeds to discuss the matter in full, after questioning Fischer-Hinnen's conclusion that these bolts never want insulating (see Abstract No. 982). In analysing the distribution of armature flux, the author points out that the currents produced in uninsulated bolts are alternating, and hence that the resistance of these bolts is more than their ohmic resistance. The author's mathematical treatment consists in dividing the instantaneous flux about any one bolt into two parts, one of which passes through the core-plates above the bolt, and the other part below the bolt. He also takes the reluctance in Oersteds of the two paths. He obtains an equation between these two quantities and the current in the bolt. It is obvious that this current tends to increase the density in the armature iron above the bolt. After giving the general equations the author takes examples from practice, and his treatment renders it necessary to obtain the actual distribution by the trial and error method. He concludes that as long as the density in C.G.S. lines per square centimetre in the iron above the bolt does not exceed 10,000 to 12,000, the loss in the bolts is not sufficient to make it worth while to insulate them. In one case, where a density of 19,250 is used, the author works out that the loss would be about 900 watts. He points out, however, that the arrangement of the bolts has much to do with preventing any flux from passing below them. In conclusion he reconciles the divergency in practice between French and Swiss electricians by the fact that in Switzerland, where alternating-current machinery is mostly used, the magnetic induction does not often exceed the limit given; in France, with direct-current machinery, higher inductions have been almost always employed. R. W. W.

1194. *Sayers' Automatic Third-Brush Regulation of Dynamos.* (Electrician, 41. pp. 358–359, 1898.)—If a third brush is arranged to bear on the commutator of a dynamo at a position midway between the ordinary brushes, the voltage between this brush and either of the other brushes will be the same when the machine is running light. When load is put on, the field becomes distorted and the voltage between the backward main brush and the third brush is reduced, while the voltage between the forward main brush and the third brush is increased. If the shunt-coils are wound to give the light-load ampere turns required with half the voltage of the machine, automatic regulation may be obtained by connecting the shunt-coils to the third brush and the forward main brush. Table I.

gives results of a test of a 120-volt 300-ampere machine with the shunt coupled in the ordinary way. Table II. gives the results of a test with the shunt coupled in parallel and one end coupled to the third brush as described; this table shows a rise of pressure on the shunt between no load and full load of 22 per cent.

The arrangement of the third brush can easily be applied to any existing machine having more than one shunt-coil in series, the coils being connected in parallel so as to adapt them for excitation with half the machine voltage.

Table I.

Revs.	Volts at brushes.	Amps.	Revs.	Volts at brushes.	Amps.
698	115·0	58	702	115·0	138
692	114·0	90	686	114·5	155
694	115·0	90	700	114·0	180
698	115·0	110	720	115·0	250
700	115·2	110	730	115·0	250
695	115·0	100			

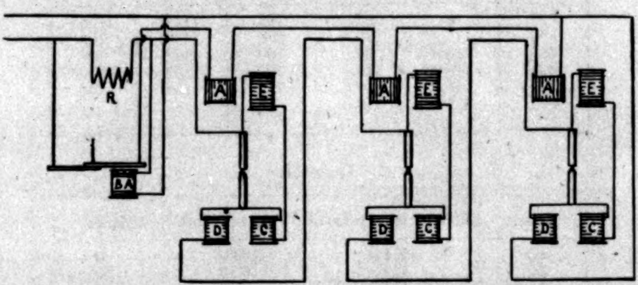
Table II.

Revs.	Volts at main brushes.	Volts on shunt.	Amps.
676	114·0	63·0	0
651	114·5	65·3	50
650	114·5	68·2	90
644	114·0	69·8	139
652	115·0	72·3	174
644	115·0	71·8	171
652	115·0	74·6	234
653	115·0	77·2	280

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1195. *Arc Lamps.* (Elekt. Runds. 15. pp. 107–108, 1898.)—This paper describes a new method of regulating arc lamps in groups of three or more connected in series with each other. This method consists in putting, immediately behind a resistance R arranged in series with and at the supply end of the mains supplying the group, a relay-coil BA in parallel with the mains. This relay BA opens and closes a circuit containing a series of shunt-coils A, A, A acting in conjunction with the feed-mechanism of each of, say, the upper carbon-holders. The feed-mechanism of each of these carbons is also controlled by an independent coil E arranged in parallel with the arc. In this manner, when the detent controlled by the relay BA and shunt-coil A and that controlled by the independent coil E are both out of engagement, the lamp will feed, but not otherwise. The feeding of each of the lower carbons is similarly controlled by two detents, one actuated by a coil D in series with the arcs (*i. e.* in the main circuit), and the other by a coil C arranged in series with the independent shunt-coil E controlling the upper carbon of each lamp. A special form of lamp is described and illustrated, in which the upper and lower carbons each actuate a separate "fly," the motion of which is controlled by detents as above mentioned. C. K. F.



1196. *Accumulators in Lighting and Traction Systems.* **J. H. Rider.** (Elect. Rev. 43. pp. 136–138 & 176–177, 1898.)—In this paper, which was read before the Municipal Electrical Association, the author describes the various applications of accumulators, showing the methods of connecting the batteries, and discusses the advantages. The energy efficiency of accumulators will seldom exceed 75 % under ordinary conditions, and the prime cost of a battery for a given output of 5 hours' discharge is given as roughly the same as for steam dynamos and boilers for the same output. The various types of lighting stations are taken in detail, and also the traction station. For the continuous-current lighting station he shows two methods of connecting up the 3-wire system. In the first, most of the dynamos are connected directly to the outer mains only, there being two separate dynamos for balancing the accumulators and the circuits, regulating cells being cut in and out as required. His opinion is, however, that the battery should be charged and discharged as a whole, so as to treat all the cells equally, and this is not possible by the first method. He therefore recommends that all the dynamos should be connected directly across the outers, two smaller ones, in series, having a middle wire-connection as well. There are no regulating-switches at all, except when the battery is being discharged, and then only on special "back E.M.F." cells. There is no necessity to vary the voltage of the dynamos during charging, as the extra voltage is added to that of the bus-bars by means of a small booster in the charging circuit, there being one on each side of the system.

For alternating-current lighting stations the use of accumulators is advocated. They can be used as a stand-by for the exciting plant, and in small stations to maintain the supply during the hours of light load, through the medium of a motor-alternator. He recommends the use of an engine, alternator, and dynamo on the same shaft, with a clutch-coupling between the engine and the two machines. During the daytime the engine would drive both, the dynamo for charging the cells, and the alternator for lighting. When the engine is shut down, the accumulators can drive the dynamo as a motor, and so drive the alternator.

The great advantages of using accumulators in traction-stations are shown by means of a load-curve, where it was found that with this addition one dynamo would easily do the work of two, and could be kept at a very regular load, so regular in fact that lighting could be done at the same time from the same machines. The battery should be connected directly to the bus-bars without any regulating switches; it must be of ample size and with a low internal resistance. To get the best effect, the dynamo should be shunt-wound with a falling characteristic, and a booster should be used during charging. A method of using a compound-wound booster is shown, whereby the battery may either be assisted to charge or discharge, depending upon whether the live current is less or greater than the output of the dynamo. Accumulators are also of great service at the end of long traction-feeders.

He recommends the use of batteries in combined lighting and traction stations, a combination which is of great service to the former. During the evening the machines would be used for lighting, and the accumulators for traction. After midnight the battery would be charged, and through the daytime it would be in parallel with the traction dynamos. The load on engines and boilers could thus be kept nearly constant all the time.

The author complains of the custom of accumulator-makers in not guaranteeing to maintain their cells at greater than about 70 °/₀ of their rated capacity, except at heavy rates, and suggests that the original rating is generally too high. AUTHOR.

1197. *Paderno High-Tension Line.* **Semenza.** (Elettricità, Milan, 17. pp. 166–169, 1898.)—There are 6 three-phase lines, the 18 wires being carried by two separate pole-lines, each having 9 wires. By putting all the load on one line, repairs can be carried out on the other, the generators being capable of giving a higher pressure to compensate for the greater drop. The wires on each pole-line are divided into three lines, so as to diminish the self-induction. The existence of three lines, however, tends to produce idle currents in wires of the same phase if any dissymmetry exists in the relative positions of the wires. The most symmetrical disposition, consistent with practice, was found to be the following:—The wires are fixed, 4 on one side and 5 on the other side of the pole, at such distances that any three consecutive wires are at the vertices of an equilateral triangle, the phases being in the order 1, 2, 3, 1, 2, 3, 1, 2, 3, alternately on each side of the pole. The distance between two consecutive wires is 600 mm., and between two wires of the same phase 1039 mm. The wires are of soft copper of 98 °/₀ conductivity, and are 9 mm. in diameter [No. 00 S.W.G.]. With spans of 60 metres the sag varies from 0·60 m. in winter to 1·20 m. in summer. The drop of volts due to the resistance and self-induction of the line and transformers is 12·5 °/₀. The loss of energy with a power-factor of 80 °/₀ is 9 °/₀. The poles are iron lattice masts, each weighing 400 kilos (880 lbs.) and have concrete foundations. At angles the two poles are connected together by diagonal cross-pieces. Two types of lightning-arresters are employed, the Würtz type, manufactured by the Westinghouse Co., and the Siemens and Halske arrester, consisting of two diverging copper wires supported on insulators. G. H. BA.

1198. *Electric Traction.* **R. C. Quin.** (Elect. Rev. 42. pp. 896–898, 1898.)—In this paper, which was read before the Municipal Electrical Association, the author deals with details of construction and working. He considers that tramway tracks are in general too lightly constructed, and recommends the method of road-construction adopted at Hamburg. In the matter of generators he has a distinct leaning towards high-speed engines without fly-wheels. He does not see the utility of fly-wheels or of uniform motion of the generators, and does not deem the latter essential to secure uniform motion of the tram-car. He defines uniform motion as motion free from perceptible jerkiness. As to gear, he considers worm-gearing efficient but unreliable, and prefers single reduction spur-gearing. He suggests that "ton mile" should be adopted as the unit of efficient working instead of the present "car mile."

On the subject of Overhead construction, he is of opinion that nothing smaller than 000 S.W.G. wire should be used, and that all section-blocks and junctions should be fitted with guard-cheeks. He recommends that the head of the trolley should be loose from the arm, and that it should be anchored by an insulated cord a short distance down the arm, as the only result of the locking of such trolley-head against the bracket-arm or suspension-wire would be its dropping free from the arm. He is further of the opinion that all guard-wires should be capable of withstanding as great a stress as the trolley line itself, and that they should be efficiently connected to earth.

Regarding systems, he believes that the local conditions necessary for the satisfactory working of the Conduit system are freedom from sand and mud on the roads, good drainage, and a wide slot. He says that the initial cost of a Conduit system varies from 30 °/₀ to 200 °/₀ in excess of the cost of an Overhead system, and that the up-keep under favourable conditions is 10 °/₀ greater than the Overhead. He considers accumulator-cars fitted to run one day's journey with one charge to be quite out of practical consideration, owing to their very heavy weight and high initial cost.

The author then deals with the figures given for the working of the Hanover Tramways on the combined Accumulator and Overhead systems; and declares that in his opinion the extra cost of the accumulator cars per mile should have been 2*d*., instead of ·2*d* as given by Mr. Epstein in his recent Institution paper. As bearing out this opinion, he quotes the figures which he obtained from the Hanover Station records as to the energy required per mile by the different types of cars. On the Accumulator system it was 1·5 units, on the combined Accumulator and Overhead cars 1·37 units, and on the Overhead cars ·68 unit. On this basis he arrives at a total cost of 2·12*d*. per car mile for accumulator car over and above that of similar cars worked on the Overhead system.

The author concludes his paper by saying that in the present state of Electric Traction Engineering there is but one good, reliable, and cheap system, viz., the Overhead; that where a combination is necessary, and conditions favourable, Overhead and Conduit come next in order of merit; and that, as at present constructed, Accumulators are not, from a commercial point of view, a satisfactory solution of the traction problem. AUTHOR.

1199. *Electric Traction on Railways.* **P. Lanino.** (Elettricità, Milan, 17. pp. 164–165 & 183–185, 1898.)—Improvements in train service take the form of greater speed and more commodious carriages, the latter necessitating greater weight. Both of these require a more powerful locomotive; but, as the permanent way limits the size and weight of the locomotive, improvement ultimately consists in reduction of weight of the motor per H.P.

The author considers that for steam-locomotives the limit has now been reached, the best types developing 1800 H.P. and weighing 154 lbs. per H.P. For progress, therefore, he looks to the electric motor fed from a central station, this being the lightest motor known; he believes that the weight can be reduced to 22 lbs. per H.P., and that the absence of any reciprocating parts removes all limit to the ultimate speed attainable.

He describes the scheme of Davis and Williamson for an electric railway between New York and Philadelphia, to run at a speed of 187 miles per hour, and of Behr for a permanent way consisting of 5 rails supported on inverted V trestles. The latter, when tried at the Brussels Exhibition of last year, failed on account of the instability of the trestles.

Criticising the Heilmann locomotive, the author expresses his opinion that this will never prove superior to the ordinary steam one, as the great disadvantage of extra weight (220 lbs. per H.P.) will outweigh the advantages of independent driving of each axle, triple expansion engines and greater regularity in the working of the engines. He believes that the present field of electric traction is that of local lines requiring frequent journeys and light trains, and cites as a successful example a three-mile trolley line opened at Baltimore in 1895. The locomotives weigh 90 tons, and have motors of a total power of 1600 H.P. distributed on six independent driving axles. The works' costs per ton mile, when 1, 2, or 3 locomotives are running, are, respectively, 0·186, 0·123, and 0·1015 pence. G. H. BA.

1200. *Efficiency of Incandescent Lamps.* **J. E. Randall.** (Mech. Eng. 1. pp. 636–638, 1898.)—The author briefly reviews the various advances made in lamp manufacture within recent years, and in illustration of the superiority of the modern cellulose filament over the older bamboo one gives the following table.

Duration of run, in hours.		0	100	200	300	400	500	600	700
Average candle-power.	110-volt Cellulose.	16	15·8	15·86	15·68	15·41	15·17	14·96	14·74
	110-volt untreated Bamboo.	16	14·1	12·9	11·8	11·0	10·4	9·9	9·6
	50-volt treated Bamboo.	16	15·8	15·3	15·0	14·6	14·2	14·0	13·7
Average watts per candle.	110-volt Cellulose.	3·16	3·26	3·13	3·37	3·53	3·51	3·54	3·74
	110-volt untreated Bamboo.	3·20	3·50	3·80	4·08	4·32	4·53	4·75	4·90
	50-volt treated Bamboo.	3·20	3·28	3·37	3·45	3·53	3·61	3·67	3·76

A. H.